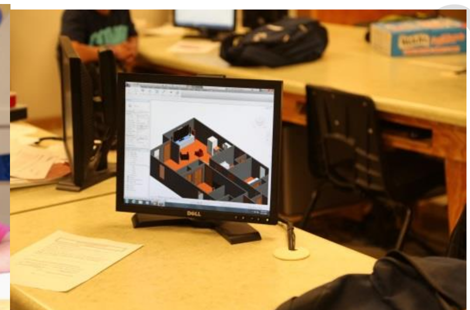
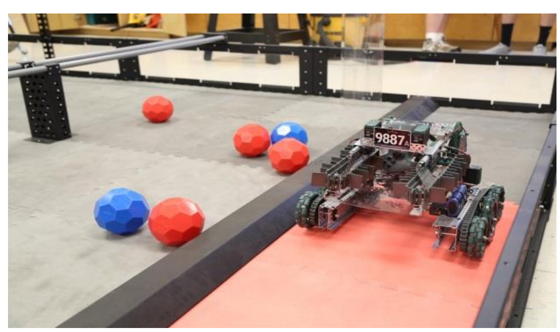
SUPPORT GUIDE
FOR GRADE EIGHT
SOUTH CAROLINA ACADEMIC STANDARDS
AND PERFORMANCE INDICATORS
FOR SCIENCE


Molly M. Spearman
State Superintendent of Education

South Carolina Department of Education
Columbia, South Carolina

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INTRODUCTION TO GRADE EIGHT STANDARDS

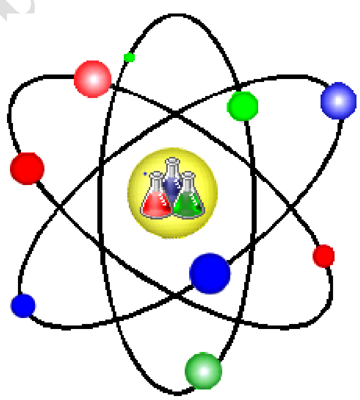
Science is a way of understanding the physical universe using observation and experimentation to explain natural phenomena. Science also refers to an organized body of knowledge that includes core ideas to the disciplines and common themes that bridge the disciplines. This document, *South Carolina Academic Standards and Performance Indicators for Science*, contains the academic standards in science for the state's students in kindergarten through grade twelve.

ACADEMIC STANDARDS

In accordance with the South Carolina Education Accountability Act of 1998 (S.C. Code Ann. § 59-18-110), the purpose of academic standards is to provide the basis for the development of local curricula and statewide assessment. Consensually developed academic standards describe for each grade and high school core area the specific areas of student learning that are considered the most important for proficiency in the discipline at the particular level.

Operating procedures for the review and revision of all South Carolina academic standards were jointly developed by staff at the State Department of Education (SCDE) and the Education Oversight Committee (EOC). According to these procedures, a field review of the first draft of the revised South Carolina science standards was conducted from March through May 2013. Feedback from that review and input from the SCDE and EOC review panels was considered and used to develop these standards.

The academic standards in this document are not sequenced for instruction and do not prescribe classroom activities; materials; or instructional strategies, approaches, or practices. The *South Carolina Academic Standards and Performance Indicators for Science* is not a curriculum.



THE PROFILE OF THE SOUTH CAROLINA GRADUATE

The *2014 South Carolina Academic Standards and Performance Indicators for Science* support the *Profile of the South Carolina Graduate*. *The Profile of the South Carolina Graduate* has been adopted and approved by the South Carolina Association of School Administrators (SCASA), the South Carolina Chamber of Commerce, the South Carolina Council on Competitiveness, the Education Oversight Committee (EOC), the State Board of Education (SBE), and the South Carolina Department of Education (SCDE) in an effort to identify the knowledge, skills, and characteristics a high school graduate should possess in order to be prepared for success as they enter college or pursue a career. The profile is intended to guide all that is done in support of college- and career-readiness.

Profile of the South Carolina Graduate

World Class Knowledge

- Rigorous standards in language arts and math for career and college readiness
- Multiple languages, science, technology, engineering, mathematics (STEM), arts and social sciences

World Class Skills

- Creativity and innovation
- Critical thinking and problem solving
- Collaboration and teamwork
- Communication, information, media and technology
- Knowing how to learn

Life and Career Characteristics

- Integrity
- Self-direction
- Global perspective
- Perseverance
- Work ethic
- Interpersonal skills

Approved by SCASA Superintendent's Roundtable and SC Chamber of Commerce.

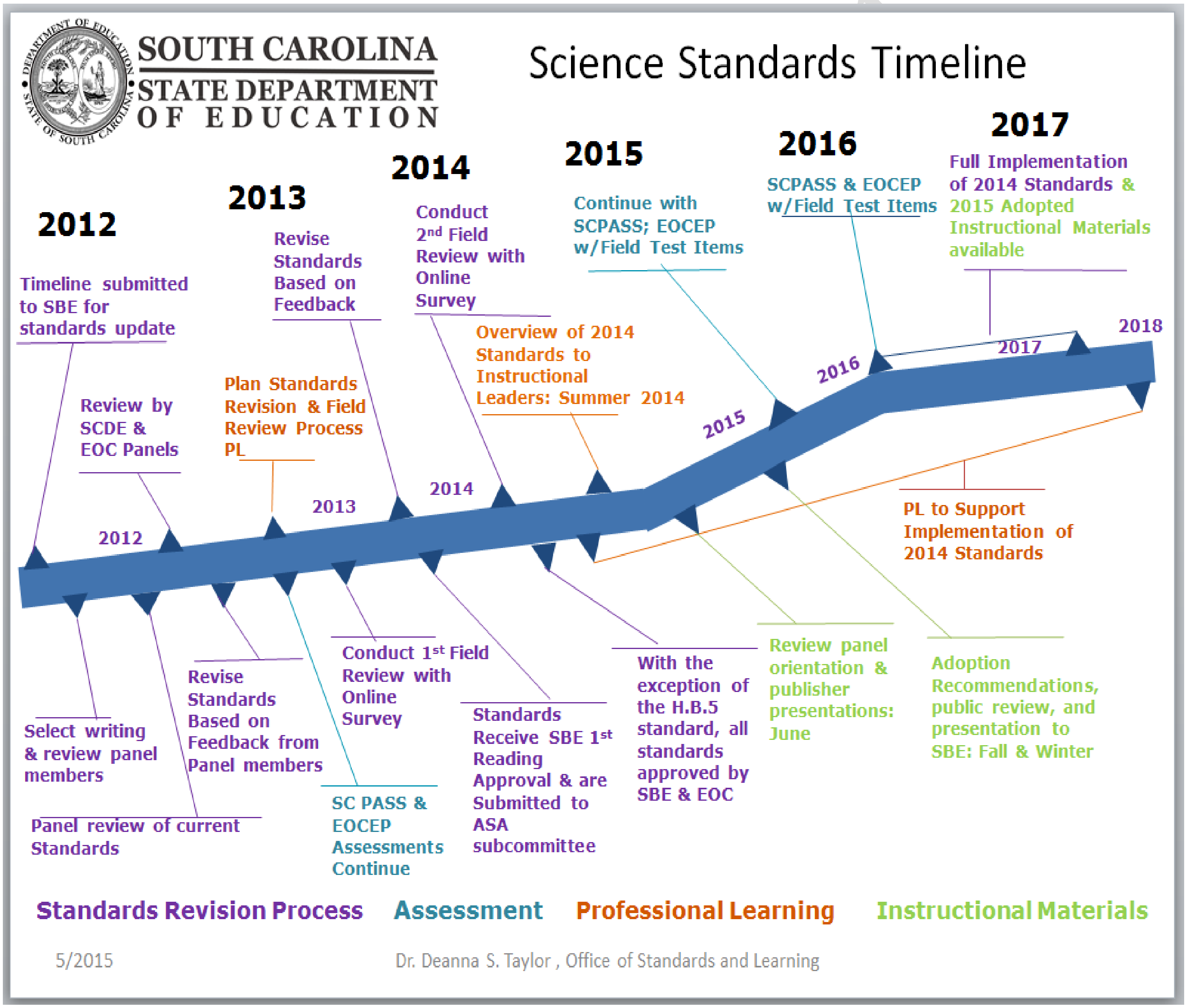
transformSC tomorrow won't wait for our students

AN INITIATIVE OF SOUTH CAROLINA COUNCIL ON COMPETITIVENESS

SCIENCE STANDARDS TIMELINE

This timeline is used to illustrate the timeline for the standards revisions process, student assessment administration, provision of professional learning and the review and adoption of instructional materials. This timeline may be used with the science academic standards, science and engineering support document, and grade/content support documents to assist local districts, schools and teachers as they construct standards-based science curriculum, allowing them to add or expand topics they feel are important and to organize content to fit their students' needs and match available instructional materials.

The timeline in this document does not offer a sequence for instruction and do not prescribe classroom activities; materials; or instructional strategies, approaches, or practices. The *Science Standards Timeline*, is not a curriculum.



CROSSCUTTING CONCEPTS

Seven common threads or themes are presented in *A Framework for K-12 Science Education* (2012). These concepts connect knowledge across the science disciplines (biology, chemistry, physics, earth and space science) and have value to both scientists and engineers because they identify universal properties and processes found in all disciplines. These crosscutting concepts are:

1. Patterns
2. Cause and Effect: Mechanism and Explanation
3. Scale, Proportion, and Quantity
4. Systems and System Models
5. Energy and Matter: Flows, Cycles, and Conservation
6. Structure and Function
7. Stability and Change

These concepts should not to be taught in isolation but reinforced in the context of instruction within the core science content for each grade level or course.

SCIENCE AND ENGINEERING PRACTICES

In addition to the academic standards, each grade level or high school course explicitly identifies S*cience and Engineering Practice* standards, with indicators that are differentiated across grade levels and core areas. The term "practice" is used instead of the term "skill," to emphasize that scientists and engineers use skill and knowledge simultaneously, not in isolation. These eight science and engineering practices are:

1. Ask questions and define problems
2. Develop and use models
3. Plan and conduct investigations
4. Analyze and interpret data
5. Use mathematical and computational thinking
6. Construct explanations and design solutions
7. Engage in scientific argument from evidence
8. Obtain, evaluate, and communicate information

Students should engage in scientific and engineering practices as a means to learn about the specific topics identified for their grade levels and courses. It is critical that educators understand that the Science and Engineering Practices are *not* to be taught in isolation. There should *not* be a distinct "Inquiry" unit at the beginning of each school year. Rather, the practices need to be employed *within the content* for each grade level or course.

Additionally, an important component of all scientists and engineers' work is communicating their results both by informal and formal speaking and listening, and formal reading and writing. Speaking, listening, reading and writing is important not only for the purpose of sharing results, but because during the processes of reading, speaking, listening and writing, scientists and engineers continue to construct their own knowledge and understanding of meaning and implications of their research. Knowing how one's results connect to previous results and what those connections reveal about the underlying principles is an important part of the scientific discovery process. Therefore, students should similarly be reading, writing, speaking and listening throughout the scientific processes in which they engage.

For additional information regarding the development, use and assessment of the *2014 Academic Standards and Performance Indicators for Science* please see the official document that is posted on the SCDE science web page--- http://tinyurl.com/2014SCScience.

DECIPHERING THE STANDARDS

KINDERGARTEN

LIFE SCIENCE: EXPLORING ORGANISMS AND THE ENVIRONMENT

Standard K.L.2: The student will demonstrate an understanding of organisms found in the environment and how these organisms depend on the environment to meet those needs.

K.L.2A. Conceptual Understanding: The environment consists of many types of organisms including plants, animals, and fungi. Organisms depend on the land, water, and air to live and grow. Plants need water and light to make their own food. Fungi and animals cannot make their own food and get energy from other sources. Animals (including humans) use different body parts to obtain food and other resources needed to grow and survive. Organisms live in areas where their needs for air, water, nutrients, and shelter are met.

Performance Indicators: Students who demonstrate this understanding can:

K.L.2A.1 Obtain information to answer questions about different organisms found in the environment (such as plants, animals, or fungi).

K.L.2A.2 Conduct structured investigations to determine what plants need to live and grow (including water and light).

Figure 1: Example from the Kindergarten Standards

The code assigned to each performance indicator within the standards is designed to provide information about the content of the indicator. For example, the **K.L.2A.1** indicator decodes as the following--

- **K: The first part of each indicator denotes the grade or subject.** The example indicator is from Kindergarten. The key for grade levels are as follows—
  - K: Kindergarten
  - 1: First Grade
  - 2: Second Grade
  - 3: Third Grade
  - 4: Fourth Grade
  - 5: Fifth Grade
  - 6: Sixth Grade
  - 7: Seventh Grade
  - 8: Eighth Grade
  - H.B: High School Biology 1
  - H.C: High School Chemistry 1
  - H.P: High School Physics 1
  - H.E: High School Earth Science

- **L: After the grade or subject, the content area is denoted by an uppercase letter.** The L in the example indicator means that the content covers Life Science. The key for content areas are as follows—

  E: Earth Science
  EC: Ecology
  L: Life Science
  P: Physical Science
  S: Science and Engineering Practices

- **2: The number following the content area denotes the specific academic standard.** In the example, the 2 in the indicator means that it is within the second academic standard with the Kindergarten science content.

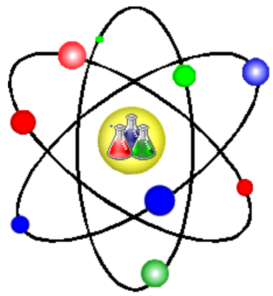
- **A: After the specific content standard, the conceptual understanding is denoted by an uppercase letter.** The conceptual understanding is a statement of the core idea for which students should demonstrate understanding. There may be more than one conceptual understanding per academic standard. The A in the example means that this is the first conceptual understanding for the standard. Additionally, the conceptual understandings are novel to the *2014 South Carolina Academic Standards and Performance Indicators for Science*.

- **1: The last part of the code denotes the number of the specific performance indicator.** Performance indicators are statements of what students can do to demonstrate knowledge of the conceptual understanding. The example discussed is the first performance indicator within the conceptual understanding.

CORE AREAS OF GRADE EIGHT SCIENCE

The five core areas of the grade eight science standards include:

- Forces and Motion
- Waves
- Earth's Place in the Universe
- Earth Systems and Resources
- Earth's History and Diversity of Life



GRADE EIGHT
SCIENCE AND ENGINEERING PRACTICES

NOTE: Scientific investigations should always be done in the context of content knowledge expected in this course. The standard describes how students should learn and demonstrate knowledge of the content outlined in the other standards.

Standard 8.S.1: The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.

8.S.1A. Conceptual Understanding: The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers.

Performance Indicators: Students who demonstrate this understanding can:

8.S.1A.1 Ask questions to (1) generate hypotheses for scientific investigations, (2) refine models, explanations, or designs, or (3) extend the results of investigations or challenge claims.

8.S.1A.2 Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others.

8.S.1A.3 Plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses, (2) identify materials, procedures, and variables, (3) select and use appropriate tools or instruments to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form. Use appropriate safety procedures.

8.S.1A.4 Analyze and interpret data from informational texts, observations, measurements, or investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning or (2) support hypotheses, explanations, claims, or designs.

8.S.1A.5 Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) collect and analyze data, (3) express relationships between variables for models and investigations, or (4) use grade-level appropriate statistics to analyze data.

8.S.1A.6 Construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams.

8.S.1A.7 Construct and analyze scientific arguments to support claims, explanations, or designs using evidence from observations, data, or informational texts.

8.S.1A.8 Obtain and evaluate scientific information to (1) answer questions, (2) explain or describe phenomena, (3) develop models, (4) evaluate hypotheses, explanations, claims, or designs or (5) identify and/or fill gaps in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or (2) reporting the results of student experimental investigations.

SCIENCE AND ENGINEERING PRACTICES *(CONTINUED)*

8.S.1B. Conceptual Understanding: Technology is any modification to the natural world created to fulfill the wants and needs of humans. The engineering design process involves a series of iterative steps used to solve a problem and often leads to the development of a new or improved technology.

Performance Indicators: Students who demonstrate this understanding can:

8.S.1B.1 Construct devices or design solutions using scientific knowledge to solve specific problems or needs: (1) ask questions to identify problems or needs, (2) ask questions about the criteria and constraints of the device or solutions, (3) generate and communicate ideas for possible devices or solutions, (4) build and test devices or solutions, (5) determine if the devices or solutions solved the problem and refine the design if needed, and (6) communicate the results.

PHYSICAL SCIENCE: FORCES AND MOTION

Standard 8.P.2: The student will demonstrate an understanding of the effects of forces on the motion and stability of an object.

8.P.2A. Conceptual Understanding: Motion occurs when there is a change in position of an object with respect to a reference point. The final position of an object is determined by measuring the change in position and direction of the segments along a trip. While the speed of the object may vary during the total time it is moving, the average speed is the result of the total distance divided by the total time taken. Forces acting on an object can be balanced or unbalanced. Varying the amount of force or mass will affect the motion of an object. Inertia is the tendency of objects to resist any change in motion.

Performance Indicators: Students who demonstrate this understanding can:

8.P.2A.1 Plan and conduct controlled scientific investigations to test how varying the amount of force or mass of an object affects the motion (speed and direction), shape, or orientation of an object.

8.P.2A.2 Develop and use models to compare and predict the resulting effect of balanced and unbalanced forces on an object's motion in terms of magnitude and direction.

8.P.2A.3 Construct explanations for the relationship between the mass of an object and the concept of inertia (Newton's First Law of Motion).

8.P.2A.4 Analyze and interpret data to support claims that for every force exerted on an object there is an equal force exerted in the opposite direction (Newton's Third Law of Motion).

8.P.2A.5 Analyze and interpret data to describe and predict the effects of forces (including gravitational and friction) on the speed and direction of an object.

8.P.2A.6 Use mathematical and computational thinking to generate graphs that represent the motion of an object's position and speed as a function of time.

PHYSICAL SCIENCE: FORCES AND MOTION *(CONTINUED)*

8.P.2A.7 Use mathematical and computational thinking to describe the relationship between the speed and velocity (including positive and negative expression of direction) of an object in determining average speed (v=d/t).

PHYSICAL SCIENCE: WAVES

Standard 8.P.3: The student will demonstrate an understanding of the properties and behaviors of waves.

8.P.3A. Conceptual Understanding: Waves (including sound and seismic waves, waves on water, and light waves) have energy and transfer energy when they interact with matter. Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter. All types of waves have some features in common. When waves interact, they superimpose upon or interfere with each other resulting in changes to the amplitude. Major modern technologies are based on waves and their interactions with matter.

Performance Indicators: Students who demonstrate this understanding can:

8.P.3A.1 Construct explanations of the relationship between matter and energy based on the characteristics of mechanical and light waves.

8.P.3A.2 Develop and use models to exemplify the basic properties of waves (including frequency, amplitude, wavelength, and speed).

8.P.3A.3 Analyze and interpret data to describe the behavior of waves (including refraction, reflection, transmission, and absorption) as they interact with various materials.

8.P.3A.4 Analyze and interpret data to describe the behavior of mechanical waves as they intersect.

8.P.3A.5 Construct explanations for how humans see color as a result of the transmission, absorption, and reflection of light waves by various materials.

8.P.3A.6 Obtain and communicate information about how various instruments are used to extend human senses by transmitting and detecting waves (such as radio, television, cell phones, and wireless computer networks) to exemplify how technological advancements and designs meet human needs.

EARTH SCIENCE: EARTH'S PLACE IN THE UNIVERSE

Standard 8.E.4: The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.

8.E.4A. Conceptual Understanding: Earth's solar system is part of the Milky Way Galaxy, which is one of many galaxies in the universe. The planet Earth is a tiny part of a vast universe that has developed over a span of time beginning with a period of extreme and rapid expansion.

Performance Indicators: Students who demonstrate this understanding can:

EARTH SCIENCE: EARTH'S PLACE IN THE UNIVERSE *(CONTINUED)*

8.E.4A.1 Obtain and communicate information to model the position of the Sun in the universe, the shapes and composition of galaxies, and the measurement unit needed to identify star and galaxy locations.

8.E.4A.2 Construct and analyze scientific arguments to support claims that the universe began with a period of extreme and rapid expansion using evidence from the composition of stars and gases and the motion of galaxies in the universe.

8.E.4B. Conceptual Understanding: Earth's solar system consists of the Sun and other objects that are held in orbit around the Sun by its gravitational pull on them. Motions within the Earth-Moon-Sun system have effects that can be observed on Earth.

Performance Indicators: Students who demonstrate this understanding can:

8.E.4B.1 Obtain and communicate information to model and compare the characteristics and movements of objects in the solar system (including planets, moons, asteroids, comets, and meteors).

8.E.4B.2 Construct explanations for how gravity affects the motion of objects in the solar system and tides on Earth.

8.E.4B.3 Develop and use models to explain how seasons, caused by the tilt of Earth's axis as it orbits the Sun, affects the length of the day and the amount of heating on Earth's surface.

8.E.4B.4 Develop and use models to explain how motions within the Sun-Earth-Moon system cause Earth phenomena (including day and year, moon phases, solar and lunar eclipses, and tides).

8.E.4B.5 Obtain and communicate information to describe how data from technologies (including telescopes, spectroscopes, satellites, space probes) provide information about objects in the solar system and the universe.

8.E.4B.6 Analyze and interpret data from the surface features of the Sun (including photosphere, corona, sunspots, prominences, and solar flares) to predict how these features may affect Earth.

EARTH SCIENCE: EARTH SYSTEMS AND RESOURCES

Standard 8.E.5: The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.

8.E.5A. Conceptual Understanding: All Earth processes are the result of energy flowing and matter cycling within and among Earth's systems. Because Earth's processes are dynamic and interactive in nature, the surface of Earth is constantly changing. Earth's hot interior is a main source of energy that drives the cycling and moving of materials. Plate tectonics is the unifying theory that explains the past and current crustal movements at the Earth's surface. This theory provides a framework for understanding geological history.

Performance Indicators: Students who demonstrate this understanding can:

8.E.5A.1 Develop and use models to explain how the processes of weathering, erosion, and deposition change surface features in the environment.

8.E.5A.2 Use the rock cycle model to describe the relationship between the processes and forces that create igneous, sedimentary, and metamorphic rocks.

8.E.5A.3 Obtain and communicate information about the relative position, density, and composition of Earth's layers to describe the crust, mantle, and core.

8.E.5A.4 Construct explanations for how the theory of plate tectonics accounts for (1) the motion of lithospheric plates, (2) the geologic activities at plate boundaries, and (3) the changes in landform areas over geologic time.

8.E.5A.5 Construct and analyze scientific arguments to support claims that plate tectonics accounts for (1) the distribution of fossils on different continents, (2) the occurrence of earthquakes, and (3) continental and ocean floor features (including mountains, volcanoes, faults and trenches).

8.E.5B. Conceptual Understanding: Natural processes can cause sudden or gradual changes to Earth's systems. Some may adversely affect humans such as volcanic eruptions or earthquakes. Mapping the history of natural hazards in a region, combined with an understanding of related geological forces can help forecast the locations and likelihoods of future events.

Performance Indicators: Students who demonstrate this understanding can:

8.E.5B.1 Analyze and interpret data to describe patterns in the location of volcanoes and earthquakes related to tectonic plate boundaries, interactions, and hot spots.

8.E.5B.2 Construct explanations of how forces inside Earth result in earthquakes and volcanoes.

8.E.5B.3 Define problems that may be caused by a catastrophic event resulting from plate movements and design possible devices or solutions to minimize the effects of that event on Earth's surface and/or human structures.

8.E.5C. Conceptual Understanding: Humans depend upon many Earth resources – some renewable over human lifetimes and some nonrenewable or irreplaceable. Resources are distributed unevenly around the planet as a result of past geological processes.

Performance Indicators: Students who demonstrate this understanding can:

8.E.5C.1 Obtain and communicate information regarding the physical and chemical properties of minerals, ores, and fossil fuels to describe their importance as Earth resources.

EARTH SCIENCE: EARTH'S HISTORY AND DIVERSITY OF LIFE

Standard 8.E.6: The student will demonstrate an understanding of Earth's geologic history and its diversity of life over time.

8.E.6A. Conceptual Understanding: The geologic time scale interpreted from rock strata provides a way to organize major historical events in Earth's history. Analysis of rock strata and the fossil record, which documents the existence, diversity, extinction, and change of many life forms throughout history, provide only relative dates, not an absolute scale. Changes in life forms are shaped by Earth's varying geological conditions.

Performance Indicators: Students who demonstrate this understanding can:

8.E.6A.1 Develop and use models to organize Earth's history (including era, period, and epoch) according to the geologic time scale using evidence from rock layers.

EARTH SCIENCE: EARTH'S HISTORY AND DIVERSITY OF LIFE *(CONTINUED)*

8.E.6A.2 Analyze and interpret data from index fossil records and the ordering of rock layers to infer the relative age of rocks and fossils.

8.E.6A.3 Construct explanations from evidence for how catastrophic events (including volcanic activities, earthquakes, climatic changes, and the impact of an asteroid/comet) may have affected the conditions on Earth and the diversity of its life forms.

8.E.6A.4 Construct and analyze scientific arguments to support claims that different types of fossils provide evidence of (1) the diversity of life that has been present on Earth, (2) relationships between past and existing life forms, and (3) environmental changes that have occurred during Earth's history.

8.E.6A.5 Construct explanations for why most individual organisms, as well as some entire taxonomic groups of organisms, that lived in the past were never fossilized.

8.E.6B. Conceptual Understanding: Adaptation by natural selection acting over generations is one important process by which species change in response to changes in environmental conditions. The resources of biological communities can be used within sustainable limits, but if the ecosystem becomes unbalanced in ways that prevent the sustainable use of resources, then ecosystem degradation and species extinction can occur.

Performance Indicators: Students who demonstrate this understanding can:

8.E.6B.1 Construct explanations for how biological adaptations and genetic variations of traits in a population enhance the probability of survival in a particular environment.

8.E.6B.2 Obtain and communicate information to support claims that natural and human-made factors can contribute to the extinction of species.

GRADE 8 CROSSWALK
FOR THE 2005 SOUTH CAROLINA SCIENCE ACADEMIC STANDARDS AND THE 2014 SOUTH CAROLINA ACADEMIC STANDARDS AND PERFORMANCE INDICATORS FOR SCIENCE

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ACKNOWLEDGEMENTS

SOUTH CAROLINA DEPARTMENT OF EDUCATION

The *Crosswalks for the South Carolina Academic Standards and Performance Indicators for Science* included in this document were developed under the direction of Dr. Julie Fowler, Deputy Superintendent, Division of College and Career Readiness and Cathy Jones Stork, Interim Director, Office of Standards and Learning.

The following South Carolina Department of Education (SCDE) staff members collaborated in the development of this document:

Dr. Deanna S. Taylor
Education Associate
Office of Standards and Learning

Dr. Regina E. Wragg
Education Associate
Office of Standards and Learning

CROSSWALK DOCUMENT REVIEW & REVISION TEAM

The following SC Educators collaborated with the SCDE to review and revise the *Crosswalks for the South Carolina Academic Standards and Performance Indicators for Science*, and their time, service, and expertise are appreciated.

Kelli Bellant (Clarendon 2)
Elizabeth Boland (Lex/Rich 5)
Michael Carothers (Lex/Rich 5)
Jami Cummings (Spartanburg 7)
Cleva Garner (Greenwood)
Constantina Green (Richland 1)
James Lillibridge (Charleston)
Jennifer McLeod (Richland 2)

Cheryl Milford (Orangeburg 3)
Jason Osborne (Beaufort)
Dominique Ragland (SCPC)
Kourtney Shumate (Darlington)
Tonya Smith (Richland 1)
Amy Steigerwalt (Charleston)
Tonya Swalgren (Lexington 1)
Pamela Vereen (Georgetown)

INTRODUCTION

This document, *Crosswalks for the 2005 South Carolina Science Academic Standards and the 2014 South Carolina Academic Standards and Performance Indicators for Science,* contains a comparison of the academic standards in science for the state's students in kindergarten through grade twelve.

HOW TO USE THE CROSSWALKS

This document may be used with the science academic standards, science and engineering support document, and grade/content support documents to assist local districts, schools and teachers as they construct standards-based science curriculum, allowing them to add or expand topics they feel are important and to organize content to fit their students' needs and match available instructional materials. 2005 and 2014 performance indicators that share similar content knowledge and skills that students should demonstrate to meet the grade level or high school course standards have been paired. These pairings have been organized into tables and are sequenced by the 2014 academic standards. The 2005 content indicators that do not match 2014 content have been placed at the end of each table. Additionally, since the conceptual understandings are novel to the *2014 South Carolina Academic Standards and Performance Indicators for Science* these portions of the crosswalk to not correlate to the *2005 South Carolina Science Academic Standards*. Conceptual understandings are statements of the core ideas for which students should demonstrate an understanding. Some grade level topics include more than one conceptual understanding with each building upon the intent of the standard.

The academic standards in this document are not sequenced for instruction and do not prescribe classroom activities; materials; or instructional strategies, approaches, or practices. The *Crosswalks for the 2005 South Carolina Science Academic Standards and the 2014 South Carolina Academic Standards and Performance Indicators for Science,* is not a curriculum.

GRADE 8 CROSSWALK DOCUMENT

(* The 2005 content indicators that do not match 2014 content have been placed at the end of each table.)

Standard 8.P.1—Science and Engineering Practices		
2005	**2014**	**Comments**
8-1: The student will demonstrate an understanding of technological design and scientific inquiry, including process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.	**8.S.1:** The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.	
Conceptual Understanding		
	8.S.1A. The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers.	
Performance Indicators		
8-1.3 Construct explanations and conclusions from interpretations of data obtained during a controlled scientific investigation.	**8.S.1A.1** Ask questions to (1) generate hypotheses for scientific investigations, (2) refine models, explanations, or designs, or (3) extend the results of investigations or challenge claims.	
	8.S.1A.2 Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others.	This is a new expectation in these standards.

8-1.1 Design a controlled scientific investigation. 8-1.2 Recognize the importance of a systematic process for safely and accurately conducting investigations. 8-1.5 Explain the importance of and requirements for replication of scientific investigations 8-1.6 Use appropriate tools and instruments (including convex lenses, plane mirrors, color filters, prisms, and slinky springs) safely and accurately when conducting a controlled scientific investigation. 8-1.7 Use appropriate safety procedures when conducting investigations.	**8.S.1A.3** Plan and conduct controlled scientific investigation to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses, (2) identify materials, procedures, and variables, (3) select and use appropriate tools or instruments to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form. Use appropriate safety procedures.	
8-1.3 Construct explanations and conclusions from interpretations of data obtained during a controlled scientific investigation.	**8.S.1A.4.** Analyze and interpret data from informational texts, observations, measurements, or investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning or (2) support hypotheses, explanations, claims, or designs.	Note that A.4 has a rich set of expectations and could be done in many instructional contexts, not just for lab investigations.
	8.S.1A.5 Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) collect and analyze data, (3) express relationships between variables for models and investigations, or (4) use grade-level appropriate statistics to analyze data.	

	8.S.1A.6 Construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams	Students constructing their own explanations, like models in A.2. is one of the hallmarks of these new standards.
	8.S.1A.7 Construct and analyze scientific arguments to support claims, explanations, or designs using evidence from observations, data, or informational texts.	Once again, compared to E-1.4, A.7 is intended to be taught in many different contexts. One of the ideas here is that hands-on investigations and activities are great, but in the end, if students can't explain the concepts they are not instructionally appropriate.
8-1.4 Generate questions for further study on the basis of prior investigations.	**8.S.1A.8** Obtain and evaluate scientific information to (1) answer questions, (2) explain or describe phenomena, (3) develop models, (4) evaluate hypotheses, explanations, claims, or designs or (5) identify and/or fill gaps in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or (2) reporting the results of student experimental investigations.	

Conceptual Understanding		
	8.S.1B. Technology is any modification to the natural world created to fulfill the wants and needs of humans. The engineering design process involves a series of iterative steps used to solve a problem and often leads to the development of a new or improved technology.	
Performance Indicators		
	8.S.1B.1 Construct devices or design solutions using scientific knowledge to solve specific problems or needs: (1) ask questions to identify problems or needs, (2) ask questions about the criteria and constraints of the device or solutions, (3) generate and communicate ideas for possible devices or solutions, (4) build and test devices or solutions, (5) determine if the devices or solutions solved the problem and refine the design if needed, and (6) communicate the results	

Standard 8.P.2—Physical Science: Forces and Motion		
2005	**2014**	**Comments**
8-5: The student will demonstrate an understanding of the effects of forces on the motion of an object.	**8.P.2:** The student will demonstrate an understanding of the effects of forces on the motion and stability of an object.	
Conceptual Understanding		
	8.P.2A. Motion occurs when there is a change in position of an object with respect to a reference point. The final position of an object is determined by measuring the change in position and direction of the segments along a trip. While the speed of the object may vary during the total time it is moving, the average speed is the result of the total distance divided by the total time taken. Forces acting on an object can be balanced or unbalanced. Varying the amount of force or mass will affect the motion of an object. Inertia is the tendency of objects to resist any change in motion.	
Performance Indicators		
8-5.4 Predict how varying the amount of force or mass will affect the motion of an object.	**8.P.2A.1** Plan and conduct controlled scientific investigations to test how varying the amount of force or mass of an object affects the motion (speed and direction), shape, or orientation of an object.	
8-5.5 Analyze the resulting effect of balanced and unbalanced forces on an object's motion in terms of magnitude and direction.	**8.P.2A.2** Develop and use models to compare and predict the resulting effect of balanced and unbalanced forces on an object's motion in terms of magnitude and direction.	

8-5.6 Summarize and illustrate the concept of inertia.	**8.P.2A.3** Construct explanations for the relationship between the mass of an object and the concept of inertia (Newton's First Law of Motion).	
8-5.5 Analyze the resulting effect of balanced and unbalanced forces on an object's motion in terms of magnitude and direction.	**8.P.2A.4** Analyze and interpret data to support claims that for every force exerted on an object there is an equal force exerted in the opposite direction (Newton's Third Law of Motion).	
8-5.3 Analyze the effects of forces (including gravity and friction) on the speed and direction of an object.	**8.P.2A.5** Analyze and interpret data to describe and predict the effects of forces (including gravitational and friction) on the speed and direction of an object.	
. 8-5.1 Use measurement and time-distance graphs to represent the motion of an object in terms of its position, direction, or speed.	**8.P.2A.6** Use mathematical and computational thinking to generate graphs that represent the motion of an object's position and speed as a function of time.	
8-5.2 Use the formula for average speed, v = d/t, to solve real-world problems	**8.P.2A.7** Use mathematical and computational thinking to describe the relationship between the speed and velocity (including positive and negative expression of direction) of an object in determining average speed (v=d/t).	

Standard 8.P.3—Physical Science: Waves		
2005	**2014**	**Comments**
8-6: The student will demonstrate an understanding of the properties and behaviors of waves.	**8.P.3:** The student will demonstrate an understanding of the properties and behaviors of waves.	
Conceptual Understanding		
	8.P.3A. Waves (including sound and seismic waves, waves on water, and light waves) have energy and transfer energy when they interact with matter. Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter. All types of waves have some features in common. When waves interact, they superimpose upon or interfere with each other resulting in changes to the amplitude. Major modern technologies are based on waves and their interactions with matter.	
Performance Indicators		
8-6.1 Recall that waves transmit energy but not matter. 8-6.2 Distinguish between mechanical and electromagnetic waves.	**8.P.3A.1** Construct explanations of the relationship between matter and energy based on the characteristics of mechanical and light waves.	
8-6.3 Summarize factors that influence the basic properties of waves (including frequency, amplitude, wavelength, and speed).	**8.P.3A.2** Develop and use models to exemplify the basic properties of waves (including frequency, amplitude, wavelength, and speed).	

8-6.4 Summarize the behaviors of waves (including refraction, reflection, transmission, and absorption).	**8.P.3A.3** Analyze and interpret data to describe the behavior of waves (including refraction, reflection, transmission, and absorption) as they interact with various materials.	
	8.P.3A.4 Analyze and interpret data to describe the behavior of mechanical waves as they intersect.	
8-6.6 Explain sight in terms of the relationship between the eye and the light waves emitted or reflected by an object 8-6.7 Explain how the absorption and reflection of light waves by various materials result in the human perception of color.	**8.P.3A.5** Construct explanations for how humans see color as a result of the transmission, absorption, and reflection of light waves by various materials.	
	8.P.3A.6 Obtain and communicate information about how various instruments are used to extend human senses by transmitting and detecting waves (such as radio, television, cell phones, and wireless computer networks) to exemplify how technological advancements and designs meet human needs.	*This performance indicator will require the knowledge of former indicator 8-6.8*

8-6.5 Explain hearing in terms of the relationship between sound waves and the ear.
8-6.8 Compare the wavelength and energy of waves in various parts of the electromagnetic spectrum (including visible light, infrared, and ultraviolet radiation).

Standard 8.E.4—Earth Science: Earth's Place in the Universe		
2005	**2014**	**Comments**
8-4: The student will demonstrate an understanding of the characteristics, structure, and predictable motions of celestial bodies. (Earth Science)	**8.E.4:** The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.	
Conceptual Understanding		
	8.E.4A. Earth's solar system is part of the Milky Way Galaxy, which is one of many galaxies in the universe. The planet Earth is a tiny part of a vast universe that has developed over a span of time beginning with a period of extreme and rapid expansion.	
Performance Indicators		
8-4.9 Recall the Sun's position in the universe, the shapes and composition of galaxies, and the distance measurement unit (light year) needed to identify star and galaxy locations.	**8.E.4A.1** Obtain and communicate information to model the position of the Sun in the universe, the shapes and composition of galaxies, and the measurement unit needed to identify star and galaxy locations	
	8.E.4A.2 Construct and analyze scientific arguments to support claims that the universe began with a period of extreme and rapid expansion using evidence from the composition of stars and gases and the motion of galaxies in the universe.	

Conceptual Understanding		
	8.E.4B. Earth's solar system consists of the Sun and other objects that are held in orbit around the Sun by its gravitational pull on them. Motions within the Earth-Moon-Sun system have effects that can be observed on Earth.	
Performance Indicators		
8-4.1 Summarize the characteristics and movements of objects in the solar system (including planets, moons, asteroids, comets, and meteors).	**8.E.4B.1** Obtain and communicate information to model and compare the characteristics and movements of objects in the solar system (including planets, moons, asteroids, comets, and meteors).	
8-4.7 Explain the effects of gravity on tides and planetary orbits.	**8.E.4B.2** Construct explanations for how gravity affects the motion of objects in the solar system and tides on Earth.	
8-4.5 Explain how the tilt of Earth's axis affects the length of the day and the amount of heating on Earth's surface, thus causing the seasons of the year.	**8.E.4B.3** Develop and use models to explain how seasons, caused by the tilt of Earth's axis as it orbits the Sun, affects the length of the day and the amount of heating on Earth's surface.	
8-4.4 Explain the motions of Earth and the Moon and the effects of these motions as they orbit the Sun (including day, year, phases of the Moon, eclipses, and tides).	**8.E.4B.4** Develop and use models to explain how motions within the Sun-Earth-Moon system cause Earth phenomena (including day and year, moon phases, solar and lunar eclipses, and tides).	
8-4.10 Compare the purposes of the tools and the technology that scientists use to study space (including various types of telescopes, satellites, space probes, and spectroscopes).	**8.E.4B.5** Obtain and communicate information to describe how data from technologies (including telescopes, spectroscopes, satellites, space probes) provide information about objects in the solar system and the universe.	

8-4.2 Summarize the characteristics of the surface features of the Sun: photosphere, corona, sunspots, prominences, and solar flares. 8-4.3 Explain how the surface features of the Sun may affect Earth.	**8.E.4B.6** Analyze and interpret data from the surface features of the Sun (including photosphere, corona, sunspots, prominences, and solar flares) to predict how these features may affect Earth.	

8-4.6 Explain how gravitational forces are influenced by mass and distance.
8-4.8 Explain the difference between mass and weight by using the concept of gravitational force.

Standard 8.E.5—Earth Science: Earth Systems and Resources		
2005	**2014**	**Comments**
8-3: The student will demonstrate an understanding of materials that determine the structure of Earth and the processes that have altered this structure. (Earth Science)	**8.E.5:** The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.	
Conceptual Understanding		
	8.E.5A. All Earth processes are the result of energy flowing and matter cycling within and among Earth's systems. Because Earth's processes are dynamic and interactive in nature, the surface of Earth is constantly changing. Earth's hot interior is a main source of energy that drives the cycling and moving of materials. Plate tectonics is the unifying theory that explains the past and current crustal movements at the Earth's surface. This theory provides a framework for understanding geological history.	

Performance Indicators		
	8.E.5A.1 Develop and use models to explain how the processes of weathering, erosion, and deposition change surface features in the environment.	
8-3.4 Explain how igneous, metamorphic, and sedimentary rocks are interrelated in the rock cycle.	**8.E.5A.2** Use the rock cycle model to describe the relationship between the processes and forces that create igneous, sedimentary, and metamorphic rocks.	
8-3.1 Summarize the three layers of Earth—crust, mantle, and core—on the basis of relative position, density, and composition.	**8.E.5A.3** Obtain and communicate information about the relative position, density, and composition of Earth's layers to describe the crust, mantle, and core.	
8-3.6 Explain how the theory of plate tectonics accounts for the motion of the lithospheric plates, the geologic activities at the plate boundaries, and the changes in landform areas over geologic time. 8-3.7 Illustrate the creation and changing of landforms that have occurred through geologic processes (including volcanic eruptions and mountain-building forces).	**8.E.5A.4** Construct explanations for how the theory of plate tectonics accounts for (1) the motion of lithospheric plates, (2) the geologic activities at plate boundaries, and (3) the changes in landform areas over geologic time.	
8-3.6 Explain how the theory of plate tectonics accounts for the motion of the lithospheric plates, the geologic activities at the plate boundaries, and the changes in landform areas over geologic time.	**8.E.5A.5** Construct and analyze scientific arguments to support claims that plate tectonics accounts for (1) the distribution of fossils on different continents, (2) the occurrence of earthquakes, and (3) continental and ocean floor features (including mountains, volcanoes, faults and trenches).	

Conceptual Understanding		
	8.E.5B. Natural processes can cause sudden or gradual changes to Earth's systems. Some may adversely affect humans such as volcanic eruptions or earthquakes. Mapping the history of natural hazards in a region, combined with an understanding of related geological forces can help forecast the locations and likelihoods of future events.	
Performance Indicators		
	8.E.5B.1 Analyze and interpret data to describe patterns in the location of volcanoes and earthquakes related to tectonic plate boundaries, interactions, and hot spots.	
8-3.8 Explain how earthquakes result from forces inside Earth.	**8.E.5B.2** Construct explanations of how forces inside Earth result in earthquakes and volcanoes.	
	8.E.5B.3 Define problems that may be caused by a catastrophic event resulting from plate movements and design possible devices or solutions to minimize the effects of that event on Earth's surface and/or human structures.	
Conceptual Understanding		
	8.E.5C. Humans depend upon many Earth resources – some renewable over human lifetimes and some nonrenewable or irreplaceable. Resources are distributed unevenly around the planet as a result of past geological processes.	

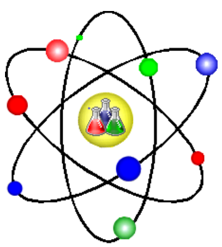
Performance Indicators		
8-3.5 Summarize the importance of minerals, ores, and fossil fuels as Earth resources on the basis of their physical and chemical properties.	**E.5C.1** Obtain and communicate information regarding the physical and chemical properties of minerals, ores, and fossil fuels to describe their importance as Earth resources.	

8-3.2 Explain how scientists use seismic waves—primary, secondary, and surface waves—and Earth's magnetic fields to determine the internal structure of Earth.
8-3.3 Infer an earthquake's epicenter from seismographic data.
8-3.9 Identify and illustrate geologic features of South Carolina and other regions of the world through the use of imagery (including aerial photography and satellite imagery) and topographic maps.

Standard 8.E.6—Earth Science: Earth's History and Diversity of Life		
2005	**2014**	**Comments**
8-2: The student will demonstrate an understanding of Earth's biological diversity over time. (Life Science, Earth Science)	**8.E.6:** The student will demonstrate an understanding of Earth's geologic history and its diversity of life over time.	
Conceptual Understanding		
	8.E.6A. Conceptual Understanding: The geologic time scale interpreted from rock strata provides a way to organize major historical events in Earth's history. Analysis of rock strata and the fossil record, which documents the existence, diversity, extinction, and change of many life forms throughout history, provide only relative dates, not an absolute scale. Changes in life forms are shaped by Earth's varying geological conditions.	

Performance Indicators		
8-2.4 Recognize the relationship among the units—era, epoch, and period—into which the geologic time scale is divided. 8-2.5 Illustrate the vast diversity of life that has been present on Earth over time by using the geologic time scale.	**8.E.6A.1** Develop and use models to organize Earth's history (including era, period, and epoch) according to the geologic time scale using evidence from rock layers.	
8-2.6 Infer the relative age of rocks and fossils from index fossils and the ordering of the rock layers.	**8.E.6A.2** Analyze and interpret data from index fossil records and the ordering of rock layers to infer the relative age of rocks and fossils.	
8-2.3 Explain how Earth's history has been influenced by catastrophes (including the impact of an asteroid or comet, climatic changes, and volcanic activity) that have affected the conditions on Earth and the diversity of its life-forms.	**8.E.6A.3** Construct explanations from evidence for how catastrophic events (including volcanic activities, earthquakes, climatic changes, and the impact of an asteroid/comet) may have affected the conditions on Earth and the diversity of its life forms.	
8-2.2 Summarize how scientists study Earth's past environment and diverse life-forms by examining different types of fossils (including molds, casts, petrified fossils, preserved and carbonized remains of plants and animals, and trace fossils).	**8.E.6A.4** Construct and analyze scientific arguments to support claims that different types of fossils provide evidence of (1) the diversity of life that has been present on Earth, (2) relationships between past and existing life forms, and (3) environmental changes that have occurred during Earth's history.	
	8.E.6A.5 Construct explanations for why most individual organisms, as well as some entire taxonomic groups of organisms, that lived in the past were never fossilized.	

Conceptual Understanding		
	8.E.6B. Adaptation by natural selection acting over generations is one important process by which species change in response to changes in environmental conditions. The resources of biological communities can be used within sustainable limits, but if the ecosystem becomes unbalanced in ways that prevent the sustainable use of resources, then ecosystem degradation and species extinction can occur.	
Performance Indicators		
8-2.1 Explain how biological adaptations of populations enhance their survival in a particular environment.	**8.E.6B.1** Construct explanations for how biological adaptations and genetic variations of traits in a population enhance the probability of survival in a particular environment.	
8-2.7 Summarize the factors, both natural and man-made, that can contribute to the extinction of a species.	**8.E.6B.2** Obtain and communicate information to support claims that natural and human-made factors can contribute to the extinction of species.	



CONTENT SUPPORT GUIDE
FOR GRADE 8
2014 SOUTH CAROLINA ACADEMIC STANDARDS
AND PERFORMANCE INDICATORS
FOR SCIENCE

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South Carolina Department of Education

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The following South Carolina Department of Education (SCDE) staff members collaborated in the development of this document:

Dr. Deanna S. Taylor
Education Associate
Office of Standards and Learning

Dr. Regina E. Wragg
Education Associate
Office of Standards and Learning

Grade 8 Curriculum Document Development Team

The following SC Educators collaborated with the SCDE to develop and draft the *Curriculum Support Guide for the South Carolina Academic Standards and Performance Indicators for Science*, and their efforts and input are appreciated.

Kourtney Shumate, Coordinator (Darlington)
Brandy Ramey, Template Keeper (Berkeley)
Tonya Smith (Richland 1)
Amy Steigerwalt (Charleston)
Michael Carothers, Coordinator (Lexington/Richland 5)
Nicole Schuldes, Template Keeper (Richland 2)
Lateasha Harris (Clarendon 1)
Cheryl Milford (Orangeburg 3)
Adrian Zongrone (EdVenture)
Maja Fickett, Coordinator (SCDE)
Vilena Hunt, Template Keeper (Aiken)
CaTia Gilbert (Beaufort)
Nina Runion (Georgetown)

Content Support Guide Revision Team

The following SC Educators collaborated with the SCDE to review, revise and compile the *Content Support Guides for the South Carolina Academic Standards and Performance Indicators for Science*, and their time, service and expertise are appreciated.

Kelli Bellant (Clarendon 2)
Elizabeth Boland (Lex/Rich 5)
Michael Carothers (Lex/Rich 5)
Jami Cummings (Spartanburg 7)
Cleva Garner (Greenwood)
Constantina Green (Richland 1)
James Lillibridge (Charleston)
Jennifer McLeod (Richland 2)
Cheryl Milford (Orangeburg 3)
Jason Osborne (Beaufort)
Dominique Ragland (SCPC)
Kourtney Shumate (Darlington)
Tonya Smith (Richland 1)
Amy Steigerwalt (Charleston)
Tonya Swalgren (Lexington 1)
Pamela Vereen (Georgetown)

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INTRODUCTION

Local districts, schools and teachers may use this document to construct standards-based science curriculum, allowing them to add or expand topics they feel are important and to organize content to fit their students' needs and match available instructional materials. The support document includes essential knowledge, extended knowledge, connections to previous and future knowledge, and assessment recommendations.

FORMAT OF THE CONTENT SUPPORT GUIDE

The format of this document is designed to be structurally uniformed for each of the academic standards and performance indicators. For each, you will find the following sections--

- **Standard**
  - This section provides the standard being explicated.
- **Conceptual Understanding**
  - This section provides the overall understanding that the student should possess as related to the standard. Additionally, the conceptual understandings are novel to the *2014 South Carolina Academic Standards and Performance Indicators for Science*.
- **Performance Indicator**
  - This section provides a specific set of content with an associated science and engineering practice for which the student must demonstrate mastery.
- **Assessment Guidance**
  - This section provides guidelines for educators and assessors to check for student mastery of content utilizing interrelated science and engineering practices.
- **Previous and Future Knowledge**
  - This section provides a list of academic content along with the associated academic standard that students will have received in prior or will experience in future grade levels. Please note that the kindergarten curriculum support document does not contain previous knowledge. Additionally, although the high school support document may not contain future knowledge, this section may list overlapping concepts from other high school science content areas.
- **Essential Knowledge**
  - This section illustrates the knowledge of the content contained in the performance indicator for which it is fundamental for students to demonstrate mastery.
- **Extended Knowledge**
  - This section provides educators with topics that will enrich students' knowledge related to topics learned with the explicated performance indicator.
- **Science and Engineering Practices**
  - This section lists the specific science and engineering practice that is paired with the content in the performance indicator. Educators should reference the chapter on this specific science and engineering practice in the *Science and Engineering Practices Support Guide.*

GRADE 8 SCIENCE CONTENT SUPPORT GUIDE

Standard 8.P.2 The student will demonstrate an understanding of the effects of forces on the motion and stability of an object.

Conceptual Understanding
8.P.2A Motion occurs when there is a change in position of an object with respect to a reference point. The final position of an object is determined by measuring the change in position and direction of the segments along a trip. While the speed of the object may vary during the total time it is moving, the average speed is the result of the total distance divided by the total time taken. Forces acting on an object can be balanced or unbalanced. Varying the amount of force or mass will affect the motion of an object. Inertia is the tendency of objects to resist any change in motion.

Performance Indicator
8.P.2A.1 Plan and conduct controlled scientific investigations to test how varying the amount of force or mass of an object affects the motion (speed and direction), shape, or orientation of an object.

Assessment Guidance
The objective of this indicator is to *plan and conduct investigations* to determine how varying the amount of force or mass of an object affects the motion (speed and direction), shape, or orientation of an object, therefore the focus of this assessment should be for students to *plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations.* This could include but is not limited to students designing and conducting experiments or simulations to demonstrate the outcome that occurs as a result of applying various amounts of force to objects that are in motion.

In addition to *plan and conduct investigations*, students should *ask questions; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations;* and *develop and use models*.

Previous and Future Knowledge
H.P.2.A (linear motion, position, displacement, velocity, acceleration)
Essential Knowledge
Speed
- *Speed* is a measure of how fast something moves a particular distance (for example, meters) over a given amount of time (for example, seconds).
- Therefore, speed is the rate of change of the position of an object, or how far something will move in a given period of time.
- Speed does not necessarily mean that something is moving fast.

Force
- If an object is in motion and more force is applied to it, the object will begin moving faster.
- If two objects have the same mass and a greater force is applied to one of the objects, the object which receives the greater force will change speeds more quickly. For example if a ball is hit harder, it will speed up faster.
- If an object must be slowed down quickly, the force applied to the object must be greater than what is needed for a gradual slowing down. For example, the greater the force applied to the brakes of a bicycle, the more quickly it will slow down or stop.

- Varying the amount of force applied to a moving object can also change the direction that the object is moving more or less quickly. For example, a baseball pitched toward the batter may quickly change direction and speed if hit very hard, or may change direction and speed more slowly if hit softly as with a bunt.

Mass

- If a heavy (more massive) object is in motion, more force must be applied to get the object moving faster.
- If the same force is applied to two objects, the object with the smaller mass will change speeds more quickly. For example if a baseball and a bowling ball are thrown with the same force the baseball will speed up faster.
- In order to slow down or stop a heavier (more massive) object, the force on that object must be greater than for a less massive object. For example, if the same braking force is applied to a small car and a large truck, the car will slow down more quickly.
- It is more difficult to change the direction of a heavy moving object, than one that is lighter in mass.

	Motion	Shape	Orientation
Force	• If an object is in motion and more force is applied to it, the object will begin moving faster. • If two objects have the same mass and a greater force is applied to one of the objects, the object which receives the greater force will change speeds more quickly. For example, if a ball is hit harder, it will speed up faster. • If an object must be slowed down quickly, the force applied to the object must be greater than what is needed for a gradual slowing down. For example, the greater the force applied to the brakes of a bicycle, the more quickly it will slow down or stop. • Varying the amount of force applied to a moving object can also change the direction that the object is moving more or less quickly. For	• Change in the shape of an object depends on the magnitude of the force that is acting on it. For example, two cars that collide traveling at lower speeds will not have as much change in shape as two cars that collide traveling at a faster speed.	• Refers to the relative position of an object. • A force can cause an object's orientation to change. For example, when two cars collide at a faster rate, there will be more change in their orientation.

	example, a baseball pitched toward the batter may quickly change direction and speed if hit very hard, or may change direction and speed more slowly if hit softly as with a bunt.		
Mass	• If a heavy (more massive) object is in motion, more force must be applied to get the object moving faster. • If the same force is applied to two objects, the object with the smaller mass will change speeds more quickly. For example, if a baseball and a bowling ball are thrown with the same force the baseball will speed up faster. • In order to slow down or stop a heavier (more massive) object, the force on that object must be greater than for a less massive object. • It is more difficult to change the direction of a heavy moving object, than one that is lighter in mass.	• Change in the shape of an object depends on the mass of the object colliding with the object. For example, a heavier car collides with a lighter car. The lighter car will sustain more changes in the shape of the car.	• A change in orientation can occur when a heavier object collides with a lighter object. For example, if a heavier car collides with a lighter car, the lighter car will have a more noticeable change in their orientation.

Extended Knowledge
Students may investigate the specific quantitative relationships among force, mass, and movement of objects (F = ma) or Newton's Laws of Motion.

Science and Engineering Practices
S.1A.3

Standard 8.P.2 The student will demonstrate an understanding of the effects of forces on the motion and stability of an object.

Conceptual Understanding
8.P.2A Motion occurs when there is a change in position of an object with respect to a reference point. The final position of an object is determined by measuring the change in position and direction of the segments along a trip. While the speed of the object may vary during the total time it is moving, the average speed is the result of the total distance divided by the total time taken. Forces acting on an object can be balanced or unbalanced. Varying the amount of force or mass will affect the motion of an object. Inertia is the tendency of objects to resist any change in motion.

Performance Indicator
8.P.2A.2 Develop and use models to compare and predict the resulting effect of balanced and unbalanced forces on an object's motion in terms of magnitude and direction.

Assessment Guidance
The objective of this indicator is to *develop and use models to* compare and predict the resulting effect of balanced and unbalanced forces on an object's motion in terms of magnitude and direction. Therefore, the primary focus of assessment should be for students to *construct drawings/diagrams and models that represent or use simulations to investigate* how balanced and unbalanced forces affect an object's motion in terms of magnitude and direction. This could include but is not limited to students developing free-body and vector diagrams to illustrate the effect balanced and unbalanced forces have on the motion of an object.

In addition to *develop and use models,* students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; obtain, evaluate, and communicate information;* and *construct devices or define solutions.*

Previous and Future Knowledge
2.P.1A.4 (Force, motion of an object)
H.P.2.B (Newton's Laws of Motion, Momentum and its Conservation, impulse and momentum, torque)

Essential Knowledge
Forces have a *magnitude* (strength) and a *direction*. Forces can be represented as arrows with the length of the arrow representing the magnitude of the force and the head of the arrow pointing in the direction of the force. Using such arrows, the resulting force (net force) and direction can be determined.
Forces acting on an object can be *balanced or unbalanced.*
Balanced forces will cause no change in the speed of an object.
- ○ Balanced forces acting on an object in opposite directions and equal in strength, as shown in the arrows below, do not cause a change in the speed of a moving object.
- ○ Objects that are not moving will not start moving if acted on by balanced forces.

For example, in arm wrestling where there is no winner, the force exerted by each person is equal, but they are pushing in opposite directions. The resulting force (net force) is zero.
- Or, in a tug of war, if there is no movement in the rope, the two teams are exerting equal, but opposite forces that are balanced. Again, the resulting force (net force) is zero.

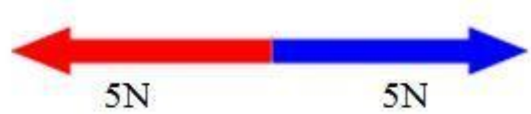


Image Source: 2005 Science Standards Support Document

Unbalanced forces are not equal, and they always cause the motion of an object to change the speed and/or direction that it is moving.

- When two unbalanced forces are exerted in opposite directions, their combined force is equal to the difference between the two forces.
- The magnitude and direction of the net force affects the resulting motion
- This combined force is exerted in the direction of the larger force
- For example, if two students push on opposite sides of a box sitting on the floor, the student on the left pushes with less force (small arrow) on the box than the student on the right side of the box (long arrow).
- The resulting action (net force: smaller arrow to the right of the = shows that the box will change its motion in the direction of the greater force as shown below:

Image Source: 2005 Science Standards Support Document

- Or, if in a tug of war, one team pulls harder than the other, the resulting action (net force) will be that the rope will change its motion in the direction of the force with the greater strength/magnitude as shown below:

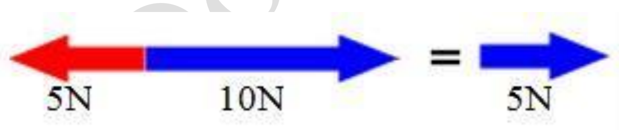


Image Source: 2005 Science Standards Support Document

- If unbalanced forces are exerted in the same direction, the resulting force (net force) will be the sum of the forces in the direction the forces are applied.
  - For example, if two people pull on an object at the same time in the same direction, the applied force on the object will be the result of their combined forces (net force or longer arrow to the right of the =) as shown below:

Image Source: 2005 Science Standards Support Document

- When forces act in the same direction, their forces are added. When forces act in opposite directions, their forces are subtracted from each other.
- Unbalanced forces also cause a nonmoving object to change its motion

- If there is no net force acting on the object, the motion does not change. If there is net force acting on an object, the speed of the object will change in the direction of the net force.

Science and Engineering Practices
S.1A.2

Standard 8.P.2 The student will demonstrate an understanding of the effects of forces on the motion and stability of an object.

Conceptual Understanding
8.P.2A Motion occurs when there is a change in position of an object with respect to a reference point. The final position of an object is determined by measuring the change in position and direction of the segments along a trip. While the speed of the object may vary during the total time it is moving, the average speed is the result of the total distance divided by the total time taken. Forces acting on an object can be balanced or unbalanced. Varying the amount of force or mass will affect the motion of an object. Inertia is the tendency of objects to resist any change in motion.

Performance Indicator
8.P.2A.3 Construct explanations for the relationship between the mass of an object and the concept of inertia (Newton's First Law of Motion).

Assessment Guidance
The objective of this indicator is to *construct explanations* for the relationship between the mass of an object and the concept of inertia (Newton's First Law of Motion); therefore the focus of assessment should be for students to *construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams* to describe the relationship between the mass of an object and the concept of inertia (Newton's First Law of Motion). This could include but is not limited to students conducting investigations or simulations to explain the effect of inertia on objects in motion, objects at rest, and the relationship between inertia and the mass of an object.

In addition to *construct explanations*, students should be asked to *ask questions; plan and carry out investigations; engage in argument from evidence; obtain, evaluate and communicate information; develop and use models; and construct devices or design solutions that demonstrate their understanding of the relationship between mass and inertia*.

Previous and Future Knowledge
H.P.2.B (Forces, Newton's Laws of Motion)
H.P.2.C (Frictional forces and free-body diagrams)

Essential Knowledge
Newton's First Law states. "The velocity of an abject will remain constant unless a net force acts on it." It is often call the *Law of Inertia.*

- If an object is moving, it will continue moving with a constant velocity (in a straight line and with a constant speed) unless a net force acts on it.
- If an object is at rest, it will stay at rest unless a net force acts on it.

- *Inertia* is the tendency of the motion of an object to remain constant in terms of both speed and direction.
- The amount of inertia that an object has is dependent on the object's mass. The more mass an object has the more inertia it has.
- If an object has a large amount of inertia (due to a large mass)
    - It will be hard to slow it down or speed it up of it is moving.
    - It will be hard to make it start moving if it is at rest.
    - It will be hard to make it change direction.
- Examples of the effects of inertia might include:
    - Inertia causes a passenger in a car to continue to move forward even though the car stops. This is the reason that seat belts are so important for the safety of passengers.
    - Inertia is the reason that it is impossible for vehicles to stop instantaneously.
    - Inertia is the reason that it is harder to start pushing a wheelbarrow full of bricks than to start pushing an empty wheelbarrow. The filled wheelbarrow has more mass and therefore, more inertia.
    - Inertia is also the reason that it is harder to stop a loaded truck going 55 miles per hour than to stop a car going 55 miles per hour. The truck has more mass resisting the change of its motion and therefore, more inertia.

Extended Knowledge
Students may study how momentum relates to inertia or practice how to calculate momentum with real-life data.

Science and Engineering Practices
S.1A.6

Standard 8.P.2 The student will demonstrate an understanding of the effects of forces on the motion and stability of an object.

Conceptual Understanding
8.P.2A Motion occurs when there is a change in position of an object with respect to a reference point. The final position of an object is determined by measuring the change in position and direction of the segments along a trip. While the speed of the object may vary during the total time it is moving, the average speed is the result of the total distance divided by the total time taken. Forces acting on an object can be balanced or unbalanced. Varying the amount of force or mass will affect the motion of an object. Inertia is the tendency of objects to resist any change in motion.

Performance Indicator
8.P.2A.4 Analyze and interpret data to support claims that for every force exerted on an object there is an equal force exerted in the opposite direction (Newton's Third Law of Motion).

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* to support claims that for every force exerted on an object there is an equal force exerted in the opposite direction (Newton's Third Law of Motion).Therefore, the primary focus of assessment should be for students to *analyze and interpret data from informational texts and data collected from investigations to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions regarding claims* that

for every force exerted on an object there is an equal force exerted in the opposite direction (Newton's Third Law of Motion). This could include but is not limited to students interpreting data from a variety of sources (diagrams, observations, informational text, charts, graphs) as evidence to support claims that for every action force there is an equal and opposite reaction force.

In addition to *analyze and interpret data*, students should be asked to *ask questions; plan and carry out investigations; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate, and communicate information; and construct devices or define solutions.*

Previous and Future Knowledge
H.P.2.B (Newton's Laws of Motion, momentum and its Conservation, impulse and momentum, torque, and free-body diagrams)

Essential Knowledge
- Newton's Third Law of Motion states, "When one object exerts a force on a second object, the second one exerts a force on the first that is equal in magnitude and opposite in direction."
  - This law is sometimes called the "Law of Action and Reaction".
  - Even though the forces are equal in magnitude and opposite in direction, they do not cancel each other. This law addresses two objects, each with only one force exerted on it.
    - Each object is exerting one force on the other object.
    - Each object is experiencing only one force.
- The action and reaction forces are reciprocal on an object.
  - Examples may include:
  - A swimmer swimming forward:
    - The swimmer pushes against the water (action force), the water pushes back on the swimmer (reaction force) and pushes her forward.
  - A ball is thrown against a wall:
    - The ball puts a force on the wall (action force), and the wall puts a force on the ball (reaction force) so the ball bounces off.
  - A person is diving off a raft:
    - The person puts a force on the raft (action force) pushing it, and the raft puts a force on the diver (reaction force) pushing them in the opposite direction.
  - A person pushes against a wall (action force), and the wall exerts an equal and opposite force against the person (reaction force).
  - The Space Shuttle engines push out hot gases (action force), and the hot gases put a force on the shuttle engines (reaction force) so the shuttle lifts (there is no sling shot doing it!)

Science and Engineering Practices
S.1A.4

Standard 8.P.2 The student will demonstrate an understanding of the effects of forces on the motion and stability of an object.

Conceptual Understanding
8.P.2A Motion occurs when there is a change in position of an object with respect to a reference point. The final position of an object is determined by measuring the change in position and direction of the segments along a

trip. While the speed of the object may vary during the total time it is moving, the average speed is the result of the total distance divided by the total time taken. Forces acting on an object can be balanced or unbalanced. Varying the amount of force or mass will affect the motion of an object. Inertia is the tendency of objects to resist any change in motion.

Performance Indicator
8.P.2A.5 Analyze and interpret data to describe and predict the effects of forces (including gravitational and friction) on the speed and direction of an object.

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* to describe and predict the effects of forces (including gravitational and frictional) on the speed and direction of an object. Therefore, the primary focus of assessment should be for students to *analyze and interpret data from informational texts and data collected from investigations and simulations to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions* to describe how forces (including gravity and friction) affect the speed and direction of an object. This could include but is not limited to students analyzing data from investigations and simulations to illustrate the effect of gravity on speed and direction, as well as varying different surfaces to determine the effect of friction on the speed and direction of an object.

In addition to *analyze and interpret data,* students should be asked to *ask questions; plan and carry out investigations; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate, and communicate information; and construct devices or define solutions*.

Previous and Future Knowledge
2.P.1A.6. (Motion and Gravity)
H.P.2.C (Coefficients of friction, frictional forces, and gravitational forces)

Essential Knowledge
It is essential for students to know:
- Forces (including gravity and friction) can affect the speed and direction of an object.

Gravity
- *Gravity* is a force that always attracts or pulls objects toward each other without direct contact or impact.
- Gravitational attraction depends on the mass of the two objects and the distance they are apart.
- Objects on Earth are pulled toward the center of Earth.
- The force of gravity, like all other forces, can cause changes in the speed of objects. As an object falls, its speed will continually increase as Earth's gravity continually pulls it downward. When air resistance is ignored, all objects will speed up at the same rate as they fall.
- Gravity can also cause an object that is thrown into the air to change its upward motion, slow down, and fall back toward Earth's surface.
- The pull of Earth's gravity keeps the Moon in orbit; the moon is constantly changing direction because of gravity.

Friction
- *Friction* is a force that occurs when one object rubs against another object. Two factors determine the amount of friction – (1) the kinds of surfaces, and (2) the force pressing the surfaces together.
- Friction is the force that acts to resist sliding between two surfaces that are touching. It can slow down or stop the motion of an object.

- The slowing force of friction always acts in the direction opposite to the force causing the motion.
    - For example, friction slows or stops the motion of moving parts of machines.
    - Another example would be athletic shoes with tread grooves to increase friction have better traction for starting or stopping motion than smooth-soled dress shoes.
- Friction can also be the force that makes it difficult to start an object moving. Enough force must be applied to a nonmoving object to overcome the friction between the touching surfaces.
- The smoother the two surfaces are, the less friction there is between them; therefore, the moving object will not slow down as quickly.
    - Friction between surfaces can be reduced, in order for objects to move more easily, by smoothing the surfaces, using wheels or rollers between the surfaces, or lubricating/oiling the surfaces.
    - If friction could be removed, an object would continue to move.
- The greater the force pushing the two surfaces together, the stronger friction prevents the surfaces from moving.
    - As an object gets heavier, the force of friction between the surfaces becomes greater.
    - To move a heavy object, a greater force must be applied to overcome the friction between the surfaces.

Extended Knowledge
Students may investigate how to calculate acceleration due to gravity, calculate weight, or the effect of gravity on different masses. Students can differentiate between static, sliding, or rolling friction.

Science and Engineering Practices
S.1A.4

Standard 8.P.2 The student will demonstrate an understanding of the effects of forces on the motion and stability of an object.

Conceptual Understanding
8.P.2A Motion occurs when there is a change in position of an object with respect to a reference point. The final position of an object is determined by measuring the change in position and direction of the segments along a trip. While the speed of the object may vary during the total time it is moving, the average speed is the result of the total distance divided by the total time taken. Forces acting on an object can be balanced or unbalanced. Varying the amount of force or mass will affect the motion of an object. Inertia is the tendency of objects to resist any change in motion.

Performance Indicator
8.P.2A.6 Use mathematical and computational thinking to generate graphs that represent the motion of an object's position and speed as a function of time.

Assessment Guidance
The objective of this indicator is to *use mathematical and computational thinking* to generate graphs that represent the motion of an object's position and speed as a function of time. Therefore the focus of assessment should be for students to *construct, use and manipulate appropriate metric units, (2) express relationships between variables for models and investigations, and (3) use grade-level appropriate statistics to analyze data* to (1) generate graphs with variables (position, direction, speed) of motion of an object's position and speed as a

function of time (2) describe the motion of an object's position and speed. This could include but is not limited to students constructing and analyzing data to explain how the speed, distance, and motion of an object changes over time.

In addition to *use mathematical and computational thinking*, students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate and communicate information; and construct devices or design solutions.*

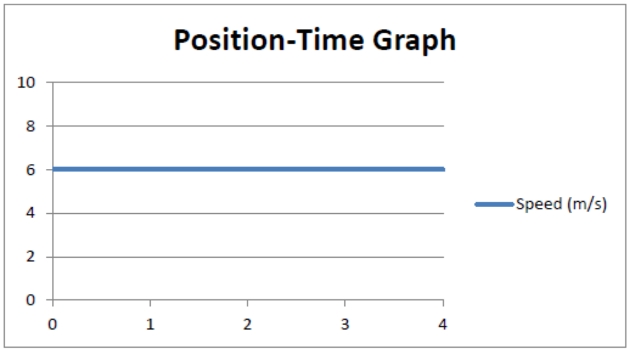
Previous and Future Knowledge
H.P.2.A (Motion, velocities and acceleration graphs)

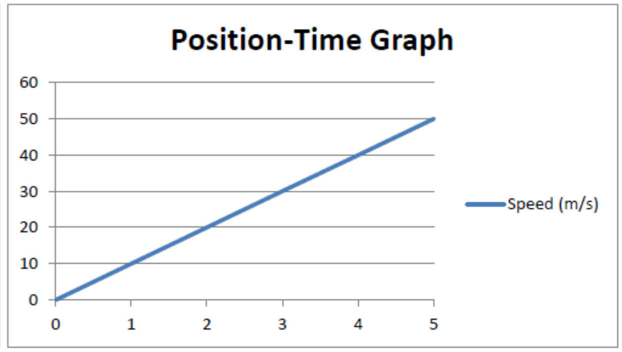
Essential Knowledge
- *Motion* occurs when there is a change in position of an object with respect to a reference starting point.
- The final position of an object is determined by measuring the change in position and direction of the segments along a trip. The following terms are used to describe and determine motion:

Position
- *Position* is the location of an object.
- An object changes position if it moves relative to a *reference point*.
- The change in position is determined by the distance and direction of an object's change in position from the starting point (*displacement*).

Direction
- *Direction* is the line, or path along which something is moving, pointing, or aiming.
- Direction is measured using a reference point with terms such as up, down, left, right, forward, backward, toward, away from, north, south, east, or west.

Speed
- The slope of the line can tell the relative speed of the object.
- When the slope of the line is steep, the speed is faster than if the slope were flatter.
- When the slope of the line is flatter, the speed is slower.
- When the slope of the line is horizontal to the x-axis, the speed is zero (the object is not moving).
- Position-Time Graphs
    - A graph used to show a change in an object's location over time.
    - For this type of graph, time (the independent variable) is plotted on the x-axis and the position (the dependent variable) is plotted on the y-axis.





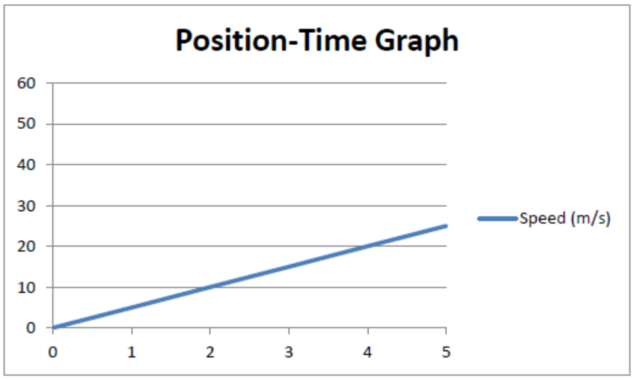


Image Source: Michael Carothers, SD5LRC; Amy Steigerwalt CCSD

NOTE: Classroom experiments should be designed so that time is being manipulated (the independent variable) and distance is the dependent variable.

It is essential for students to:

- Construct position/time graphs from data showing the distance traveled over time for selected types of motion (rest, constant velocity).
- Compare the shape of these three types of graphs and recognize the type of motion from the shape of the graph.
- Discuss in words the significance of the shapes of the graphs in terms of the motion of the objects.

Extended Knowledge
Students could learn about situations and calculate momentum problems.

Science and Engineering Practices
S.1A.5

Standard 8.P.2 The student will demonstrate an understanding of the effects of forces on the motion and stability of an object.

Conceptual Understanding
8.P.2A Motion occurs when there is a change in position of an object with respect to a reference point. The final position of an object is determined by measuring the change in position and direction of the segments along a trip. While the speed of the object may vary during the total time it is moving, the average speed is the result of the total distance divided by the total time taken. Forces acting on an object can be balanced or unbalanced. Varying the amount of force or mass will affect the motion of an object. Inertia is the tendency of objects to resist any change in motion.

Performance Indicator
8.P.2A.7 Use mathematical and computational thinking to describe the relationship between the speed and velocity (including positive and negative expression of direction) of an object in determining average speed (v=d/t).

Assessment Guidance
The objective of this indicator is to *use mathematical and computational thinking* to describe the relationship between the speed and velocity (including positive and negative expression of direction) of an object in determining average speed (v=d/t). Therefore the focus of assessment should be for students to *construct, use and manipulate appropriate metric units, express relationships between variables for models and investigations, and use grade-level appropriate statistics to analyze data* to describe the relationship between speed and velocity (including positive and negative expression of direction). This could include but is not limited to students conducting investigations or simulations to gather data for calculating average speed.

In addition to *use mathematical and computational thinking*, students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate and communicate information;* and *construct devices or design solutions*.

Previous and Future Knowledge
H.P.2A (Describing linear motion, position, displacement, velocity and acceleration)

Essential Knowledge
- Average speed can be calculated by dividing the total distance the object travels by the total amount of time it takes to travel that distance.
- While the speed of the object may vary during the total time it is moving, the average speed is the result of the *total distance* divided by the *total time* taken.
- Speed measurements contain a unit of distance divided by a unit of time. Examples of units of speed might include "meters per second" (m/s), "kilometers per hour" (km/h), or "miles per hour" (mph or mi/hr).
- Average speed can be calculated using the formula v=d/t where the variables are:
  - ***v*** is the average speed of the object with units of m/s
  - ***d*** is the total distance or length of the path of the object with units of m
  - ***t*** is the total time taken to cover the path with units of s
  - Speed cannot have a negative value.

- Velocity refers to both the speed of an object and the direction of its motion. (For the intent of this indicator, disregard the direction of the motion.)

- A velocity value should have both speed units and direction units, such as m/sec north, km/h south, cm/s left, or km/min down.

- If an object is moving forward, it has positive velocity. When an object is moving backwards, it has negative velocity.
  - When you throw a ball in the air, it has positive velocity. When it heads back towards you, it has negative velocity.

Extended Knowledge
Students may investigate how acceleration is the rate of change in velocity. Students may solve problems for time or distance.

Science and Engineering Practices
S.1A.5

Standard 8.P.3 The student will demonstrate an understanding of the properties and behaviors of waves.

Conceptual Understanding
8.P.3A Waves (including sound and seismic waves, waves on water, and light waves) have energy and transfer energy when they interact with matter. Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter. All types of waves have some features in common. When waves interact, they superimpose upon or interfere with each other resulting in changes to the amplitude. Major modern technologies are based on waves and their interactions with matter.

Performance Indicator
8.P.3A.1 Construct explanations of the relationship between matter and energy based on the characteristics of mechanical and light waves.

Assessment Guidance
The objective of this indicator is to *construct explanations of* the relationship between matter and energy based on the characteristics of mechanical and light waves; therefore the focus of assessment should be for students to *construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams* to describe the relationship between matter and energy based upon this evidence. This could include but is not limited to students comparing structural diagrams of mechanical and light waves and using evidence from these diagrams to differentiate how matter and energy are transferred through the two types of waves.

In addition to *construct explanations*, students should be asked to *ask questions; plan and carry out investigations; engage in argument from evidence; obtain, evaluate and communicate information; develop and use models;* and *construct devices or design solutions.*

Previous and Future Knowledge
H.P.3D (Mechanical Waves, Wave Interference, Principle of Superposition, Doppler Effect, Properties of Waves)
H.P.3F (Electromagnetic spectrum, Reflection, Refraction and Diffraction, Ray Approximation)

Essential Understanding
A *wave* is a repeating disturbance or vibration that transfers or moves energy from place to place.
- Waves are created when a source of energy (force) causes a vibration.
- A *vibration* is a repeated back-and-forth or up-and-down motion.
- Waves carry energy through empty space or through a *medium* without transporting matter.
- While all waves can transmit energy through a medium, certain waves can also transmit energy through empty space.
- A *medium* is a material through which waves can travel. It can be a solid, liquid, or gas.

- When waves travel through a medium, the particles of the medium are not carried along with the wave.
- When there is no medium, certain waves (electromagnetic) can travel through empty space

Characteristics of mechanical and electromagnetic waves:

Mechanical waves

- *Mechanical waves* require the particles of the medium to vibrate in order for energy to be transferred.
- For example, water waves, earthquake/seismic waves, sound waves, and the waves that travel down a rope or spring are also mechanical waves.
- Sound waves, as with all mechanical waves, cannot be transferred or transmitted through empty space *(vacuum*).

Light waves

- Are considered e*lectromagnetic waves* which are waves that can travel through matter or empty space where matter is not present.
- Light waves are the only part of the electromagnetic spectrum that is visible to the human eye.

Another way to classify waves is by how they move:

- Mechanical waves in which the particles of matter in the medium vibrate by pushing together and moving apart parallel to the direction in which the wave travels are called *compressional* or *longitudinal waves*.
    - The place on the wave that is pushed together is called the *compression* and the place that is moving apart is the *rarefaction*.
    - Examples of mechanical compressional/longitudinal waves might include sound waves and some seismic waves.
- Mechanical waves in which the particles of matter in the medium vibrate by moving back and forth and perpendicular (at right angles) to the direction the wave travels are called *transverse waves*.
- The highest point of a transverse wave is the *crest* and the lowest point is called a *trough*.
- Examples of mechanical transverse waves might include some waves in a slinky spring, waves on a rope, strings in a musical instrument, and some seismic waves
- Light waves are transverse waves that can travel without a medium through empty space.

Extended Knowledge

- Students may explore the mechanisms (the oscillations of the fields) by which energy is transferred through empty space.

Science and Engineering Practices

S.1A.6

Standard 8.P.3 The student will demonstrate an understanding of the properties and behaviors of waves.

Conceptual Understanding

8.P.3A Waves (including sound and seismic waves, waves on water, and light waves) have energy and transfer energy when they interact with matter. Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter. All types of waves have some features in common. When waves interact, they superimpose upon or interfere with each other resulting in changes to the amplitude. Major modern technologies are based on waves and their interactions with matter.

Performance Indicator

8.P.3A.2 Develop and use models to exemplify the basic properties of waves (including frequency, amplitude, wavelength, and speed).

Assessment Guidance
8.P.3A.2 The objective of this indicator is to *develop and use models* to exemplify the basic properties of waves (including frequency, amplitude, wavelength, and speed). Therefore, the primary focus of assessment should be for students to *construct drawings/diagrams and models that represent or use simulations to investigate* the basic properties of waves (including frequency, amplitude, wavelength, and speed). This could include but is not limited to students using simulations and conducting experiments that use materials such as rope and metal springs to model wave properties.

In addition to *develop and use models*, students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; obtain, evaluate, and communicate information;* and *construct devices or define solutions.*

Previous and Future Knowledge
H.P.3D (Mechanical Waves, Wave Interference, Principle of Superposition, Doppler Effect, Properties of Waves)

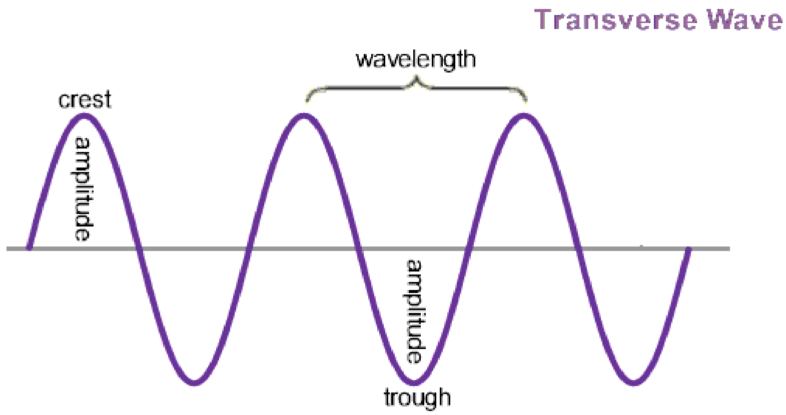
Essential Knowledge
Frequency
- *Frequency* is a measure of how many waves pass a point in a certain amount of time.
- The higher the frequency, the closer the waves are together and the greater the energy carried by the waves will be.

Amplitude
- *Amplitude* is a measure of the distance between a line through the middle of a wave and a crest or trough.
- The greater the force that produces a wave, the greater the amplitude of the wave and the greater the energy carried by the wave.
- In a transverse wave the higher the wave, the higher the amplitude.
- Sounds with greater amplitude will be louder; light with greater amplitude will be brighter.

Wavelength
- *Wavelength* is a measure of the distance from the crest on one wave to the crest on the very next wave.
- Shorter wavelengths are influenced by the frequency.
- A higher frequency causes a shorter wavelength and greater energy.

Speed
- *Speed* is a measure of the distance a wave travels in an amount of time.
- The speed of a wave is determined by the type of wave and the nature of the medium.
- As a wave enters a different medium, the wave's speed changes. Waves travel at different speeds in different media.
- All frequencies of electromagnetic waves travel at the same speed in empty space.

NOTE: Properties of waves will be diagrammed using transverse waves only.
- The highest point of a transverse wave is the *crest* and the lowest point is called a *trough*.



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Extended Knowledge
Students can investigate how to calculate the speed of a wave or how to diagram these properties on a longitudinal wave.

Science and Engineering Practices
S.1A.2

Standard 8.P.3 The student will demonstrate an understanding of the properties and behaviors of waves.

Conceptual Understanding
8.P.3A Waves (including sound and seismic waves, waves on water, and light waves) have energy and transfer energy when they interact with matter. Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter. All types of waves have some features in common. When waves interact, they superimpose upon or interfere with each other resulting in changes to the amplitude. Major modern technologies are based on waves and their interactions with matter.

Performance Indicator
8.P.3A.3 Analyze and interpret data to describe the behavior of waves (including refraction, reflection, transmission, and absorption) as they interact with various materials.

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* to describe the behavior of waves (including refraction, reflection, transmission, and absorption) as they interact with various materials. Therefore, the primary focus of assessment should be for students to *analyze and interpret data from informational texts and data collected from investigations to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions* that describes the behavior of waves (including refraction, reflection, transmission, and absorption as they interact with various materials. This could include but is not limited to students conducting simulations or experiments (1) using different types of materials to create and observe the behavior of mechanical waves and (2) using various light sources, optic devices, and solid materials to observe the behavior of light waves.

In addition to *analyze and interpret data*, students should be asked to *ask questions; plan and carry out investigations; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate, and communicate information;* and *construct devices or define solutions.*

Previous and Future Knowledge
4.P.4A.5 (Light moves in a straight line. Transparent, translucent, and opaque materials)
4.P.4A.1 (Prism and Visible light spectrum)
H.P.3D (Mechanical Waves, Wave Interference, Principle of Superposition, Doppler Effect, Properties of Waves)
H.P.3F (Electromagnetic spectrum, Reflection, Refraction and Diffraction, Ray Approximation)

Essential Understanding
In addition to the properties of waves discussed 8.P.3A.2,

- Waves have the following behaviors:

Refraction

- *Refraction* is the bending of waves caused by a change in their speed as they pass from one medium to another.
- As waves pass at an angle from one medium to another, they may speed up or slow down.
- The greater the change in speed of the waves, the more the waves will bend.
- Refraction of light going from air through a *convex lens*, for example, can make images appear larger as the light waves bend.
- *Prisms* or *diffraction gratings* separate white light into its different components or colors by bending the light at different angles depending on the frequencies of the light passing through the prism or diffraction grating. Different colors of light have different frequencies.

Reflection

- *Reflection* is the bouncing back of a wave when it meets a surface or boundary that does not absorb the entire wave's energy.
- All types of waves can be reflected.
- Reflections of sound waves, for example, are called echoes and help bats and dolphins learn about their environments.
- *Plane mirrors* and other smooth surfaces reflect light to form clear images.

Transmission

- *Transmission* of waves occurs when waves pass through a given point or medium.
- Sound waves are transmitted through solids, liquids, and gases.
- Light waves are transmitted through *transparent* materials (may be clear or colored material such as filters) that allow most of the light that strikes them to pass through them.
- Only a small amount of light is reflected or absorbed.
- *Opaque* materials allow no light waves to be transmitted through them.
- *Translucent* materials transmit some light, but cause it to be scattered so no clear image is seen.

Absorption

- *Absorption* of certain frequencies of light occurs when the energy is not transferred through, or reflected by, the given medium.
- Objects or substances that *absorb* any wavelength of electromagnetic radiation become warmer and convert the absorbed energy to infrared radiation.

Extended Knowledge
Students may explore the quantitative relationships in refraction, reflection, absorption, or transmission of waves. Students may investigate the behavior of diffraction and polarization of light. Measuring angles of reflection or refraction can be investigated. Behaviors using concave lenses or convex mirrors and concave mirrors may also be investigated.

Science and Engineering Practices
S.1A.4

Standard 8.P.3 The student will demonstrate an understanding of the properties and behaviors of waves.

Conceptual Understanding
8.P.3A Waves (including sound and seismic waves, waves on water, and light waves) have energy and transfer energy when they interact with matter. Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter. All types of waves have some features in common. When waves interact, they superimpose upon or interfere with each other resulting in changes to the amplitude. Major modern technologies are based on waves and their interactions with matter.

Performance Indicator
8.P.3A.4 Analyze and interpret data to describe the behavior of mechanical waves as they intersect.

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* to describe the behavior of mechanical waves as they intersect. Therefore, the primary focus of assessment should be for students to *analyze and interpret data from informational texts and data collected from investigations to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions* regarding the behavior of mechanical waves as they intersect. This could include but is not limited to students collecting and analyzing data from experiments and simulations using different types of materials to create mechanical waves and observe the behavior of these waves as they intersect.

In addition to *analyze and interpret data*, students should be asked to *ask questions; plan and carry out investigations; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate, and communicate information;* and *construct devices or define solutions*.

Previous and Future Knowledge
H.P.3D (Mechanical Waves, Wave Interference, Principle of Superposition, Doppler Effect, Properties of Waves)

Essential Knowledge
- Waves interfere with each other.
- Interference may be constructive:
  - A crest will interfere with another crest constructively to produce a larger crest and a trough will interfere to produce a larger trough.
  - Compressions interfere constructively with each other as do rarefactions.
- Interference may be destructive:
  - A crest will interfere with a trough to lessen or cancel the displacement of each.

    - Compressions interfere with rarefactions to lessen or cancel the displacement of each.
- Sound waves *interfere* with each other changing what you hear.
    - Destructive interference makes sounds quieter; constructive interference makes sounds louder.
    - Sound waves reflect in tubes or some musical instruments to produce standing waves which reinforce sound through constructive interference to make the sound louder.

Science and Engineering Practices
S.1A.4

Standard 8.P.3 The student will demonstrate an understanding of the properties and behaviors of waves.

Conceptual Understanding
8.P.3A Waves (including sound and seismic waves, waves on water, and light waves) have energy and transfer energy when they interact with matter. Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter. All types of waves have some features in common. When waves interact, they superimpose upon or interfere with each other resulting in changes to the amplitude. Major modern technologies are based on waves and their interactions with matter.

Performance Indicator
8.P.3A.5 Construct explanations for how humans see color as a result of the transmission, absorption, and reflection of light waves by various materials.

Assessment Guidance
The objective of this indicator is to *construct explanations* for how humans see color as a result of the transmission, absorption, and reflection of light waves by various materials. Therefore the focus of assessment should be for students *to construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams.* This could include but is not limited to students (1) observing models of the eye to diagram and sequence the interaction between light and the eye that allows sight and the perception of color and (2) collecting and analyzing data from simulations and experiments using materials of different colors and color filters to explain why we see color.

In addition to *construct explanations*, students should be asked to *ask questions; plan and carry out investigations; engage in argument from evidence; obtain, evaluate and communicate information; develop and use models;* and *construct devices or design solutions.*

Previous and Future Knowledge
H.P.3F (Electromagnetic spectrum, Reflection, Refraction and Diffraction, Ray Approximation)

Essential Understanding
- The interaction between the eye and light emitted or reflected by an object allows sight to occur as follows:
    - Light waves that have been emitted or reflected by an object, enter the eye and first pass through the transparent layer called the *cornea* where they are refracted.
    - The light rays are then refracted again as they pass through the transparent *lens* (convex).
    - The lens focuses the light waves on the *retina*, located on the back of the inside of the eye.

- The retina is composed of tiny light sensitive nerves that transfer the energy of the light waves to nerve impulses transmitted through the *optic nerve* to the brain for interpretation as *sight*.
- The absorption and reflection of light waves by various materials results in human perception of color as follows:
  - Most materials absorb light of some frequencies and reflect the rest.
  - If a material absorbs a certain frequency of light, that frequency will not be reflected, so its color will not be perceived by the observer.
  - If the material does not absorb a certain frequency of light, that frequency will be reflected, so its color will be perceived by the observer.
  - If all colors of light are reflected by a material, it will appear white. If all colors of light are absorbed by a material, it will appear black.
- The color that we see depends on
  - (1) the color of light that is shined on the object and
  - (2) the color of light that is reflected by the object.
  - For example, if an object reflects red wavelengths and absorbs all others, the object will appear red in color.
- *Color filters* allow only certain colors of light to pass/transmit through them; they absorb or reflect all other colors.
  - For example, a blue filter only transmits blue light.
  - Objects seen through a blue filter will look blue if the objects reflect blue; objects of other colors will appear black because the other color wavelengths are being absorbed by the filter.

Extended Knowledge

- Students may research knowledge about vision problems, such as being nearsighted or farsighted.
- Students may explore which frequencies of light are perceived as which colors. The mixing of primary colors of light or of primary pigments may also be investigated.

Science and Engineering Practices
S.1A.6

Standard 8.P.3 The student will demonstrate an understanding of the properties and behaviors of waves.

Conceptual Understanding
8.P.3A Waves (including sound and seismic waves, waves on water, and light waves) have energy and transfer energy when they interact with matter. Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter. All types of waves have some features in common. When waves interact, they superimpose upon or interfere with each other resulting in changes to the amplitude. Major modern technologies are based on waves and their interactions with matter.

Performance Indicator
8.P.3A.6 Obtain and communicate information about how various instruments are used to extend human senses by transmitting and detecting waves (such as radio, television, cell phones, and wireless computer networks) to exemplify how technological advancements and designs meet human needs.

Assessment Guidance
The objective of this indicator is to *obtain information* about how various instruments are used to extend human senses by transmitting and detecting waves. Therefore, the primary focus of assessment should be for students

to *obtain and evaluate informational texts, observations, data collected or discussions to (1) generate and answer questions, (2) understand, (3) develop models, or (4) support explanations* regarding how technological advancements and designs meet human needs by transmitting and detecting waves. This could include but is not limited to students researching and using evidence to discuss how radios, televisions, cell phones, and wireless computer networks extend human senses by transmitting and detecting radio waves.

In addition to *obtain information*, students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models;* and *construct devices or define solutions.*

Previous and Future Knowledge
H.P.3F (Electromagnetic spectrum)

Essential Knowledge
The electromagnetic spectrum depicts the range of all possible frequencies of electromagnetic radiation. Radio waves are classed as low frequency, high-wavelength energy waves, and gamma rays are classed as high-frequency, low-wavelength energy waves.

Signals that humans cannot sense directly can be detected through technological advances and designs. Radios, televisions, cell phones and wireless computer networks are examples of such technologies that are beneficial to humans by receiving and transmitting signals through radio waves. These signals are transmitted through a medium (which can include the air or fiber optic cables) and captured by the device. The higher the frequency of the radio wave, the more information it can carry. For example, the radio waves transmitted and received by wireless computer networks are at much higher frequencies than those used by other devices. Radios, televisions, and cell phones cannot detect these waves that carry the enormous amounts of information required for internet usage.

The signals sent and received by radios, televisions, cell phones and wireless networks are often digitized (sent as wave pulses) as a more reliable way to transmit information. When in digitized form, information can be recorded, stored for future recovery, and transmitted over long distances without substantial loss.

Extended Knowledge
Students may develop models of antique and novel types of radios, televisions, cell phones and wireless networks to compare and contrast the parts of these devices that send and receive wave signals. Students may also plan and carry out investigations that determine which materials block and which materials transmit radio waves using a remote control car.

Science and Engineering Practices
S.1A.8

Standard 8.E.4 The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.

Conceptual Understanding
8.E.4A Earth's solar system is part of the Milky Way Galaxy, which is one of many galaxies in the universe. The planet Earth is a tiny part of a vast universe that has developed over a span of time beginning with a period of extreme and rapid expansion.

Performance Indicator
8.E.4A.1 Obtain and communicate information to model the position of the Sun in the universe, the shapes and composition of galaxies, and the measurement unit needed to identify star and galaxy locations

Assessment Guidance
The objective of this indicator is to *obtain and communicate information* to model the position of the Sun in the universe, the shapes and composition of galaxies, and the measurement unit needed to identify star and galaxy locations. Therefore, the primary focus of this assessment should be for students to *obtain and evaluate informational texts, observations, data collected or discussions to (1) generate and answer questions, (2) understand, (3) develop models, or (4) support explanations regarding* the position of the Sun, the composition and shapes of galaxies, and the measurement used to identify star and galaxy locations. This could include, but is not limited to students using primary and secondary sources of information to develop a model to show the Sun's location in the universe, students developing models to compare the shapes and composition of the galaxies, and developing models to demonstrate how the light year is used as the unit of measure between stars and galaxies.

In addition to *obtain and communicate information* students should be asked to *ask questions; analyze and interpret data; use mathematical and computational thinking; construct explanations;* and *develop and use models.*

Previous and Future Knowledge
H.E.2 (Structure, properties, and history of the observable universe)

Essential Knowledge
- The Sun is a star in the Milky Way galaxy located in a spiral arm about two-thirds of the way from the center of the galaxy.
- *Galaxies* are made up of gas, dust, and billions of stars and have different shapes
    - *elliptical* – spherical or flattened disks,
    - *spiral* – a nucleus of bright stars and two or more spiral arms, or
    - *irregular* – no definite shape
- Because distances in space are so great that conventional numbers are too large to work with, astronomers use a unit of measurement called *light year* to measure the distance to stars and galaxies in space. The distance in one light year is equal to the distance light travels in one year.

Extended Knowledge
There are multiple historical figures that have contributed to our current understanding of the Sun's location in the Milky Way. The following are included:
- Johannes Kepler
- Galileo Galilei
- Tycho Brahe

Light travels 9.46×10^{12} km (5.88×10^{12} miles) in a year. This means that the light that we are seeing from objects in the sky is from the past. The light from our star leaves the surface of the Sun 8 minutes before it reaches us. The light from the nearest large galaxy, Andromeda, was emitted 2.5 million years ago. Therefore, the images we see of these objects are how they looked at the time in the past when their light left them. The further away an object is, the older the light is that we are receiving from it.

The shapes of galaxies can change over time as a result of various factors including collisions with other galaxies and the evolution of the galaxy itself.

Astronomers use a method called parallax to determine how far away stars are. Stars seem to shift their position when viewed from Earth because of Earth's revolution about the Sun. This is referred to as a parallax shift. Astronomers use the diameter of Earth's orbit to determine the parallax angle across the sky.

Science and Engineering Practices
S.1A.8

Standard 8.E.4 The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.

Conceptual Understanding
8.E.4A Earth's solar system is part of the Milky Way Galaxy, which is one of many galaxies in the universe. The planet Earth is a tiny part of a vast universe that has developed over a span of time beginning with a period of extreme and rapid expansion.

Performance Indicator
8.E.4A.2 Construct and analyze scientific arguments to support claims that the universe began with a period of extreme and rapid expansion using evidence from the composition of stars and gases and the motion of galaxies in the universe.

Assessment Guidance
The objective of this indicator is to *construct scientific arguments* to support claims that the universe began with a period of extreme and rapid expansion using evidence from the composition of stars and gases and the motion of galaxies in the universe. Therefore the primary focus of this assessment should be for students to *use information from primary and secondary sources* about the composition of stars and nebulae as well as the relative motion of galaxies to construct scientific arguments to support claims regarding the age of the universe and that the universe began with a period of extreme and rapid expansion. This could include but is not limited to students 1) researching how the composition of stars and nebulae can be used to determine their age and 2) use red-shift data to support claims that the universe is expanding.

In addition to *constructing scientific arguments to support claims*, students should be asked to *ask questions; analyze and interpret data; use mathematics and computational thinking; construct explanations;* and *obtain, evaluate, and communicate information.*

Previous and Future Knowledge
H.E.2 (Structure, properties, and history of the observable universe)

Essential Knowledge
The universe is composed of matter and energy. All of the matter in the universe now was in the universe when it formed. There is evidence to support that scientists are able to estimate the age of the universe in two ways
- by looking for the oldest stars
  - Nebula (gas and dust) exist in space and are remnants from the formation of the universe.
  - Stars undergo a life cycle based on the composition of the gases within them. As stars age the amount of hydrogen in the star changes, therefore changing the color and brightness of the star.
- by measuring the rate of expansion of the universe
  - Astronomers determined the galaxy is expanding based on the color of light emitted from

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galaxies and stars.
  - As the universe expands and galaxies move apart, the wave-length of light emitted from those galaxies is stretched. This shifts the light toward the red end of the spectrum and is called "red-shift". The more distance or faint a galaxy the more rapidly it is moving away from Earth.

Extended Knowledge
- Knowledge of the movement of galaxies and stars has advanced as we have made developments in space technology.
- Students can use spectrometers to measure emission lines from stars.
- Students can develop models to show how expansion results in an increase in wavelength which produces red-shift.
- Students can research additional resources regarding the evidence scientists use to support the argument that the universe is expanding as well as the age of the universe.

Science and Engineering Practices
S.1A.7

Standard 8.E.4 The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.

Conceptual Understanding
8.E.4B Earth's solar system consists of the Sun and other objects that are held in orbit around the Sun by its gravitational pull on them. Motions within the Earth-Moon-Sun system have effects that can be observed on Earth.

Performance Indicator
8.E.4B.1 Obtain and communicate information to model and compare the characteristics and movements of objects in the solar system (including planets, moons, asteroids, comets, and meteors).

Assessment Guidance
The objective of this indicator is to *obtain and communicate information* to model and compare the characteristics and movements of objects in the solar system (including planets, moons, asteroids, comets, and meteors). Therefore, the primary focus of assessment should be for students to *obtain information through observations, data collected or discussions, as well as primary and secondary sources, to develop models that describe and compare* the characteristics and movements of objects in the solar system (including planets, moons, asteroids, comets, and meteors) This could include but is not limited to students obtaining and communicating information to develop models that 1) describe the differences between terrestrial and gaseous planets, 2) demonstrates how other objects in the solar system (moons, asteroids, comets, meteorites, meteoroids, etc.) compare to each other, and 3) describe how all of these objects move in relation to each other (including the difference between rotation and revolution).

In addition to *obtain information,* students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations;* and *develop and use models*.

Previous and Future Knowledge
4.E.3 (Solar System)
H.E.2 (Structure, properties, and history of the observable universe)

Essential Knowledge
Objects found in the *solar system* have characteristics based on surface features and atmosphere (if there is one). These objects move via orbit/revolution and/or rotation.

Planets

- Planets may have either a terrestrial/rocky surface or a gaseous surface. Gaseous planets are considerably larger than terrestrial planets.
- Planets may have rings or other unique surface characteristics.
- Movement of planets is based on revolution around the Sun and rotation on the planet's axis.

Moons

- Moons are studied in relation to the planet they orbit. Not all planets have moons.
- Most are rocky bodies covered with craters, but some have unique characteristics.
- Movement of moons is based on revolution around their planets and rotation on their axis.

Asteroids

- Most asteroids are rocky bodies that orbit in a region in the solar system known as the Asteroid Belt between Mars and Jupiter.
- They vary in size and shape.
- Movement is based on their revolution around the Sun.
- Some asteroids outside the asteroid belt have orbits that cross Earth's orbit, which require scientists to monitor their positions.

Comets

- Comets have a main body or head (ice, methane and ammonia and dust) and a tail that emerges as the comet gets closer to the Sun during its orbit.
- The effects of the solar winds result in the tail always points away from the Sun.
- Comets have long, narrow, elliptical orbits that cause them to cross paths with other objects in the solar system.
- Most comets originate from regions of the solar system that lie beyond the orbit of Neptune.

Meteors

- Meteors are chunks of rock that burn upon entering a planet's atmosphere.
- Prior to entering the atmosphere the chunks of rock move about within the solar system and are known as meteoroids.
- When the chunk of rock strikes the surface of a planet or moon it is known as a *meteorite*.

Extended Knowledge

- Factors affecting the appearance of impact craters include the size, mass, speed and angle of the falling object.
- The solar system consists of the Sun and a collection of objects of varying sizes and conditions—including planets and their moons—that are held in orbit around the Sun by its gravitational pull on them.
- Planetary motions around the Sun can be predicted using Kepler's three empirical laws, which can be explained based on Newton's theory of gravity.
- Students can research the likelihood that Earth will be struck by a large object from space, what might be the outcome of such a collision (students can look at historical impacts as well as predict the results of future impacts), what we are doing to identify those objects, and what we might be able to do to avoid such collisions.
- Students can describe the unique characteristics of the planets and/or of the major moons that are found in our solar system.

- Students can research dwarf planets and argue from scientific information as to whether or not this new classification is needed.

Science and Engineering Practices
S.1A.8

Standard 8.E.4 The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.

Conceptual Understanding
8.E.4B Earth's solar system consists of the Sun and other objects that are held in orbit around the Sun by its gravitational pull on them. Motions within the Earth-Moon-Sun system have effects that can be observed on Earth.

Performance Indicator
8.E.4B.2 Construct explanations for how gravity affects the motion of objects in the solar system and tides on Earth.

Assessment Guidance
The objective of this indicator is to *construct explanations* for how gravity affects the motion of objects in the solar system and tides on Earth. Therefore, the focus of assessment should be for students to *construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams* to describe tides on Earth or the movement of objects in the solar system. This could include but is not limited to students (1) comparing images of tides as a way to construct explanations regarding the effect of gravity on tidal range, (2) develop and use models of objects in the solar system to communicate an explanation for how the gravity of objects in our solar system affect the movements of other bodies in our solar system, and (3) gathering and analyzing data during investigations to support an explanation of the effect of the gravitational pull of the Sun and the Moon on the Earth.

In addition to *construct explanations*, students should be asked to *ask questions; plan and carry out investigations; engage in argument from evidence; obtain, evaluate and communicate information;* and *develop and use models.*

Previous and Future Knowledge
H.E.2 (Structure, properties, and history of the observable universe)

Essential Knowledge
Tides and planetary orbits are caused by the pull of gravity.
Effects of Mass and Distance on Gravitational Force
- The more massive an object, the greater it's gravitational pull.
- The closer the distance between objects, the greater the gravitational pull
- The gravitational pull between the Sun and the planets and between Earth and its Moon cause distinct motions between and among these bodies

Effects of Gravity on Planetary Orbits
- The Sun's gravitational attraction, along with the planet's inertia (continual forward motion), keeps the planets moving in elliptical orbits (Earth's orbit is slightly oval) and determines how fast they orbit.

- Planets nearer the Sun move/orbit faster than planets farther from the Sun because the gravitational attraction is greater.
- When a planet is farther from the Sun, the gravitational attraction between them decreases and the planet moves/orbits slower.

Effects of Gravity on Tides

- Since the Moon is closer to Earth than the Sun (distance), the Moon has the greatest pulling effect on tides, the rise and fall of Earth's waters.
- The Sun also pulls on Earth and
    - can combine its force with the Moon causing even higher tides, spring tides
    - or can be a right angles, pulling against the Moon's pull, causing very little tidal change, *neap tides*.

Extended Knowledge

- Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system.

Science and Engineering Practices
S.1A.6

Standard 8.E.4 The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.

Conceptual Understanding
8.E.4B Earth's solar system consists of the Sun and other objects that are held in orbit around the Sun by its gravitational pull on them. Motions within the Earth-Moon-Sun system have effects that can be observed on Earth.

Performance Indicator
8.E.4B.3 Develop and use models to explain how seasons, caused by the tilt of Earth's axis as it orbits the Sun, affects the length of the day and the amount of heating on Earth's surface.

Assessment Guidance
The objective of this indicator is to *develop and use models* to explain how seasons, caused by the tilt of Earth's axis as it orbits the Sun, affects the length of the day and the amount of heating on Earth's surface. Therefore, the primary focus of assessment should be for students to *construct drawings/diagrams, models, and simulations that depict* how seasons occur. This could include but is not limited to students (1) developing a model to illustrate the effects of the tilt of Earth's axis as it orbits the Sun and (2) developing models that illustrate the angle of sunlight at various locations on Earth depending on the season and latitude.

In addition to *develop and use models*, students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations;* and *obtain, evaluate, and communicate information.*

Previous and Future Knowledge
4.E.3 (Solar Systems)
H.E.5 (Earth's atmosphere)

Essential Knowledge

- The Earth's axis remains pointed in the same direction at all times as the Earth revolves around the Sun.
- The combination of the revolution around the Sun and the fixed angle of the Earth's axis result in the following seasonal changes: temperature changes, angle of sunlight, number of daylight hours.
- As Earth revolves around the Sun, the tilt of its axis (23½ degrees) determines the amount of time that the Sun is shining on a specific portion of Earth. The tilt remains at the same angle and points in the same direction as Earth revolves around the Sun. This difference in the amount of time that an area receives sunlight results in changes in the length of day.
- When the tilt of Earth is toward the Sun in a particular hemisphere, there is a longer length of day and the season is summer.
- When both hemispheres are receiving the same amount of sunlight, the length of day and night is equal. This occurs in fall/autumn and spring.
- When the tilt of Earth is away from the Sun in a particular hemisphere, there is a shorter length of day and the season is winter.
- The combination of direct rays from the Sun that strike Earth at higher angles (closer to 90 degrees) and more daylight hours causes the hemisphere of Earth tilted toward the Sun to have warmer temperatures.
- The combination of indirect rays from the Sun that strike Earth at lower angles and less hours of daylight in the hemisphere of Earth angled away from the Sun have cooler temperatures.

Extended Knowledge

- At latitudes beyond 66.5 degrees north and south (the Arctic Circle and Antarctic Circle), there are "days" and "nights" that last for a month or for months. During the "day" period, the Sun never fully sets and during the "night" period the Sun never fully rises.
- The only region of the Earth that ever receives sunlight at 90 degrees is between the Tropics of Cancer (23.5 degrees north) and Capricorn (23.5 degrees south).
- The changes in seasons affect living things in many different ways. These changes can stimulate living things to enter dormancy or hibernation, enter into courtship behaviors, develop structures for reproduction, and/or many other responses.
- Over the course of Earth's history, the Earth's axis has wobbled. This means that the Earth's axis has not always been pointed in the same direction. When combined with variations in the tilt of the Earth's axis and the distance the Earth is from the Sun, the result is an approximately 100,000 year cycle of ice ages.
- Migratory animals sense the change in the amount of daylight (photoperiod) and respond by migrating.

Science and Engineering Practices
S.1A.2

Standard 8.E.4 The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.

Conceptual Understanding
8.E.4B Earth's solar system consists of the Sun and other objects that are held in orbit around the Sun by its gravitational pull on them. Motions within the Earth-Moon-Sun system have effects that can be observed on Earth.

Performance Indicator
8.E.4B.4 Develop and use models to explain how motions within the Sun-Earth-Moon system cause Earth phenomena (including day and year, Moon phases, solar and lunar eclipses, and tides).

Assessment Guidance
The objective of this indicator is to *develop and use models* to explain how motions within the Sun-Earth-Moon system cause Earth phenomena (including day and year, Moon phases, solar and lunar eclipses, and tides). Therefore, the primary focus of assessment should be for students to *construct drawings/diagrams, models, and simulations that represent* how the motions of the Sun-Earth-Moon system result in phenomena such as days/years, Moon phases, eclipses, and tides. This could include but is not limited to students 1) develop models of how the phases of the Moon are caused by the relative position and motion of the Moon as it moves around the Earth, 2) develop models of how daily and monthly changes in tidal activity result from the position of the Moon relative to the Earth and the Sun as well as the Earth's rotation on its axis, 3) develop a model that simulates how the rotation and revolution of the Earth around the Sun result in day and night as well as the year, and 4) develop models to describe how the relative positions of the Sun, Earth, and Moon, result in the various types of eclipses.

In addition to *develop and use models*, students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations;* and *obtain, evaluate, and communicate information.*

Previous and Future Knowledge
- 4.E.3: The student will demonstrate an understanding of the locations, movements, and patterns of stars and objects in the solar system. Key Words: astronomy, solar system, Sun, Moon, Earth, orbit, rotation, revolution, axis, tilt, day, night, seasons, angle of sunlight
- H.E.2: The student will demonstrate an understanding of the structure, properties, and history of the observable universe. **Key words:** motion of orbiting objects in the solar system (Kepler's Laws)

Essential Knowledge
All bodies in the solar system are in constant motion.
Day
- The Earth rotates on its axis as it revolves around the Sun. It takes approximately 24 hours, a *day*, for a complete rotation to occur. This counterclockwise motion occurs from west to east, causing the Sun to appear to rise in the east and set in the west.

Year
- While the Earth rotates on its axis, it is also revolving around the Sun. It takes 365 ¼ days, a *year*, for this motion/orbit to occur.
- The Earth revolves around the Sun in an *elliptical* orbit.

Lunar Movement
- The Moon rotates on its axis and revolves around the Earth as the Earth revolves around the Sun.
- It takes about 27 Earth days for the Moon to rotate on its axis and about 29 ½ Earth days *(month)* for it to revolve around the Earth.
- Because the Moon's period of rotation on its axis and period of revolution around the Earth are nearly the same, the same side of the Moon always faces Earth.
- Changes in the Moon's position as it revolves around the Earth results in more or less of the sunlight reflected form the Moon being visible when observing the Moon from the Earth. This causes the Moon to appear to change shape.

Phases of the Moon

- New Moon- The Moon is positioned between the Sun and the Earth so that the side of the Moon that is viewed from Earth is cannot be seen. Because of this, there appears to be no Moon in the night sky.
- Full Moon- The Sunlit portion of the Moon is facing the Earth while the Earth is positioned between the Sun and Moon. The Moon is visible in the sky.
- The Sunlit portion of the Moon that is visible from Earth appears to either increases (waxes) or decreases (wanes), as the Moon orbits the Earth.
- Crescent Moon-either waxing or waning; less than ½ of the Sunlit portion of the Moon is visible.
- Gibbous Moon-either waxing or waning; Greater than ½ of the Sunlit portion of the Moon is visible.
- First/Third Quarter-1/2 of the Sunlit portion of the Moon is visible.
    - A first quarter follows the waxing crescent.
    - A third quarter occurs when ½ of the Moon is visible.

Eclipses

- *Eclipses* occur when an object in space passes directly between two other objects or between the object and the viewer.
- *A solar eclipse* occurs when the Moon passes directly between the Sun and Earth, blocking the Sun's light and casting a shadow over a certain area on Earth. This can only occur during a New Moon.
- *A lunar eclipse* occurs when Earth passes directly between the Sun and the Moon, blocking the Sun's light so that Earth's shadow hits the Moon casting a shadow over the Moon. This can only occur during a Full Moon.
- An eclipse does not occur at every New Moon and Full Moon because of the angle of the Moon's orbit around the Earth.

Tides

- Tides are the rise and fall of the surface levels of Earth's ocean water caused by the gravitational effects of the Sun and Moon on Earth. The effects of tides are most noticeable along ocean shorelines.
- As the Moon orbits Earth, the waters of Earth closest to the Moon bulge outward toward the Moon. This bulge is the high tide. Another high tide occurs on the opposite side of Earth. Low tides occur in the areas between the two high tides.
- As the Earth rotates on its axis, any given location will rotate into and out of the tidal bulge. This results in the changes between high and low tides over the course of 24 hours.
- When the Sun and the Moon are aligned so that the Moon is between the Sun and the Earth (New Moon) or the Earth is between the Sun and the Moon (Full Moon) high tides are higher and the low tides are lower. These are called spring tides. When the Sun and the Moon are at right angles to each other (first and last quarter), lower high tides and higher low tides are experienced. These tides are called *neap tides*.

Extended Knowledge

Scientists can study the top layer of the Sun during some solar eclipses. The Moon blocks the brightest rays of sunlight. This makes it easier for scientists to see the top layer of the Sun.

If the Earth had no atmosphere, then the Moon would be completely black during a total eclipse. Instead, the Moon can take on a range of colors from dark brown and red to bright orange and yellow. The exact appearance depends on how much dust and clouds are present in Earth's atmosphere. Total eclipses tend to be very dark after major volcanic eruptions since these events dump large amounts of volcanic ash into Earth's atmosphere.

The orbit of the Moon around the Earth is inclined about 5.1 degrees when compared to the Earth's orbit around the Sun. This is the reason that eclipses do not occur with every New and Full Moon; the shadows do not line up.

The Moon orbiting the Earth affects the timing of high and low tides. This results in these tides occurring at different times every day,

Science and Engineering Practices
S.1A.2

Standard 8.E.4 The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.

Conceptual Understanding
8.E.4B Earth's solar system consists of the Sun and other objects that are held in orbit around the Sun by its gravitational pull on them. Motions within the Earth-Moon-Sun system have effects that can be observed on Earth.

Performance Indicator
8.E.4B.5 Obtain and communicate information to describe how data from technologies (including telescopes, spectroscopes, satellites, space probes) provide information about objects in the solar system and the universe.

Assessment Guidance
The objective of this indicator is to *obtain and communicate information* to describe how data from technologies (including telescopes, spectroscopes, satellites, space probes) provide information about objects in the solar system and the universe. Therefore, the primary focus of assessment should be for students to *obtain and communicate information from a variety of sources (informational texts, observations, data collected or discussions) to support explanations* regarding the use of space technology in gathering information about objects in the solar system. This could include but is not limited to students gathering information from a variety of sources and tools to communicate details regarding how data from these technologies provide information about objects in the solar system and the universe.

In addition to *obtain information*, students should be asked to *ask questions; analyze and interpret data; use mathematics and computational thinking; and engage in argument from evidence;* and *construct explanations.*

Previous and Future Knowledge
4.E.3 (Solar System)
H.E.2: (Structure, properties, and history of the observable universe)

Essential Knowledge
Astronomers use telescopes, satellites, space probes, and spectroscopes to make observations and collect data about objects inside the solar system and outside the solar system. These tools and the associated technology that allow astronomers to analyze and interpret the data help scientists learn about the solar system and about the universe.
Telescopes

- Refractor telescopes use convex lenses to bend and focus light rays to produce images of objects in space.

- Reflector telescopes use mirrors to focus light rays to produce images of objects in space.
- Radio telescopes receive radio waves emitted from objects in space, including waves from very distant stars and galaxies. Then the radio waves are used to produce images of the objects from sound waves. Radio telescopes receive information in any weather and during day or night.
- Other telescopes "read" infrared or x-ray signals but have to be placed where Earth's atmosphere does not block or absorb the signals.

Satellites and Space Observatories

- Satellites are placed in orbit around Earth with special instruments and telescopes that collect information from space. The information is sent back to Earth where it is interpreted.
- Space Observatories are telescopes or other instruments that have been launched into outer space to collect data on distant planets, galaxies, and other celestial bodies. The Hubble Space Telescope is an example of a space observatory.
- Data gathered from satellites and space observatories are not hampered by Earth's atmosphere.

Space probes

- *Space probes* contain instruments to collect data and travel out of Earth's orbit to explore places that would be too dangerous for astronomers; the instruments that a probe contains depends upon the space mission.

Spectroscopes

- *Spectroscopes* collect the light from distant stars and separate that light into bands of different colors; by studying these bands, astronomers identify the elements in a star.

Extended Knowledge
Remote sensing data is used to provide information about bodies in space. Students can review this data to determine how scientists use it to refine our understanding of the universe. One area of current research is the search for exoplanets. Data is collected from a variety of sources to determine the location of planets outside of our solar system. As more accurate data is collected, planets of smaller sizes are being located.

Science and Engineering Practices
S.1A.8

Standard 8.E.4 The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.

Conceptual Understanding
8.E.4B Earth's solar system consists of the Sun and other objects that are held in orbit around the Sun by its gravitational pull on them. Motions within the Earth-Moon-Sun system have effects that can be observed on Earth.

Performance Indicator
8.E.4B.6 Analyze and interpret data from the surface features of the Sun (including photosphere, corona, Sunspots, prominences, and solar flares) to predict how these features may affect Earth.

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* from the surface features of the Sun (including photosphere, corona, Sunspots, prominences, and solar flares) to predict how these features may affect Earth. Therefore, the primary focus of assessment should be for students to *analyze and interpret data from informational texts to support explanations or claims* regarding how the features of the Sun may affect Earth.

This could include but is not limited to using data from a variety of sources (diagrams, observations, informational text) to describe the surface features and activities of the Sun and to make predictions for how these features and activities can affect the Earth.

In addition to *analyze and interpret data*, students should be asked to *ask questions; plan and carry out investigations; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models;* and *obtain, evaluate, and communicate information.*

Previous and Future Knowledge
4.E.3 (Solar System)

Essential Knowledge

- The *photosphere* is the visible surface of the Sun that emits the light that we see. It is the lowest layer of the Sun's atmosphere.
- The *corona*, the outer most layer of the Sun's atmosphere, also emits light but is only visible as a white halo during a solar eclipse.
- *Sunspots* appear as dark spots on the photosphere. They are actually moving areas of magnetic activity with temperatures that are cooler than the area of the photosphere in which they are located. Astronomers study Sunspot cycles to learn how changes in solar activity affect life on Earth.
- *Prominences* are bright arch-like loops that may erupt from the photosphere into the corona. Often associated with Sunspot activity, they release large amounts of energy into outer space.
- *Solar flares* occur near Sunspots and are sudden, intense explosions that result in changes in brightness when magnetic energy is released. The charged particles released by solar flares are often detected in Earth's atmosphere. The energy released from solar flares can cause damage to the International Space Station, disrupt radio and electrical transmissions on Earth, and cause displays of bright lights, auroras, that appear to "dance" in the skies near the North and South Poles.

Extended Knowledge
Students can research how Sunspots, prominences, and solar flares are related.
Students can explore solar wind and describe how it can affect conditions on Earth and cause atmospheric phenomena.
Students can describe how these activities can release energies and particles that can interact with living things and man-made objects.

Science and Engineering Practices
S.1A.4

Standard 8.E.5 The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.

Conceptual Understanding
8.E.5A All Earth processes are the result of energy flowing and matter cycling within and among Earth's systems. Because Earth's processes are dynamic and interactive in nature, the surface of Earth is constantly changing. Earth's hot interior is a main source of energy that drives the cycling and moving of materials. Plate tectonics is the unifying theory that explains the past and current crustal movements at the Earth's surface. This theory provides a framework for understanding geological history.

Performance Indicator

8.E.5A.1 Develop and use models to explain how the process of weathering, erosion, and deposition change surface features in the environment.

Assessment Guidance
The objective of this indicator is to *develop and use models* to explain how the processes of weathering, erosion, and deposition change surface features in the environment. Therefore, the focus of assessment should be for students to *construct representations to illustrate, predict, and explain* how weathering, erosion, and deposition change Earth's surface features. This could include but is not limited to students using data from a variety of sources (stream tables, computer simulations, informational text) to develop models that show how weathering, erosion, and deposition change surface features.

In addition to *develop and use models*, students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; engage in argument from evidence; construct explanations;* and *obtain, evaluate, and communicate information.*

Previous and Future Knowledge
5.E.3: (Natural processes and human activities affect the features of Earth's landforms and oceans.
H.E.3: (Internal and external dynamics of Earth's geosphere)

Essential Knowledge
Weathering, erosion, and deposition are processes that act together to wear down and builds up Earth's surface. These processes have occurred for billions of years.
Weathering is any process that breaks down rocks and creates sediments. There are two forms of weathering, chemical and mechanical (physical).

- Chemical weathering is decomposition of rock caused by chemical reactions resulting in formation of new compounds.
- Mechanical (physical) weathering is the breakdown of rock into smaller pieces.

Erosion is the process by which natural forces move weathered rock and soil from one place to another.

- Gravity, running water, glaciers, waves, and wind all cause erosion. The material moved by erosion is sediment.

Deposition occurs when the agents (wind or water) of erosion lay down sediment.

- Deposition changes the shape of the land.

Erosion, weathering, and deposition are at work everywhere on Earth. Gravity pulls everything toward the center of Earth causing rock and other materials to move downhill. Water's movements (both on land and underground) cause weathering and erosion, which change the land's surface features and create underground formations. The effects of these processes are as follows:

- Changes in shape, size, and texture of landforms (i.e. mountains, riverbeds, and beaches).
- Landslides
- Buildings, statues, and roads wearing away.
- Soil formation
- Washes soil, pollutants, harmful sediments into waterways.
- Causes metals to rust
- Reduces beaches, shorelines.
- Forms new landforms.

Extended Knowledge
Geologic cycle is a collective term used to describe the complex interactions between the component sub-cycles of tectonic, hydrologic, rock, and the biological cycling of elements known as the biogeochemical cycle. These various sub-cycles influence each other and may produce natural hazards and processes important to environmental geology such as landslides, earthquakes, volcanic activity, flooding, groundwater flow, and weather. The rock cycle is influenced by all the other geologic sub-cycles.

Science and Engineering Practices
S.1A.2

Standard 8.E.5 The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.

Conceptual Understanding
8.E.5A All Earth processes are the result of energy flowing and matter cycling within and among Earth's systems. Because Earth's processes are dynamic and interactive in nature, the surface of Earth is constantly changing. Earth's hot interior is a main source of energy that drives the cycling and moving of materials. Plate tectonics is the unifying theory that explains the past and current crustal movements at the Earth's surface. This theory provides a framework for understanding geological history.

Performance Indicator
8.E.5A.2 Use the rock cycle model to describe the relationship between the processes and forces that create igneous, sedimentary, and metamorphic rocks.

Assessment Guidance
The objective of this indicator is *to use models* to describe the relationship between the processes and forces that create igneous, sedimentary, and metamorphic rocks. Therefore, the focus of assessment should be for students to use the rock cycle model to explain how rocks form and can change from one form to another. This could include but is not limited to students demonstrating the cause and effect relationship between different geologic processes and the formation, and transformation, of different types of rocks with visual representations, written explanations, and/or simulations of the rock cycle.

In addition to *using models*, students should be asked to *ask questions; plan and carry out investigations; engage in argument from evidence; construct explanations;* and *obtain, evaluate, and communicate information.*

Previous and Future Knowledge
3.E.4 (Composition of Earth)
H.E.3 (Internal and external dynamics of Earth's geosphere)
Essential Knowledge
There are three large classifications of rocks – igneous, metamorphic, and sedimentary. Each type of rock is formed differently and can change from one type to another over time. The way rocks are formed determines how we classify them.
Igneous
- Forms when molten rock (magma or lava) cools and hardens.
- If cooling takes place slowly beneath Earth's surface, the igneous rock is called intrusive.
- If the cooling takes place rapidly on Earth's surface, the igneous rock is called *extrusive*.

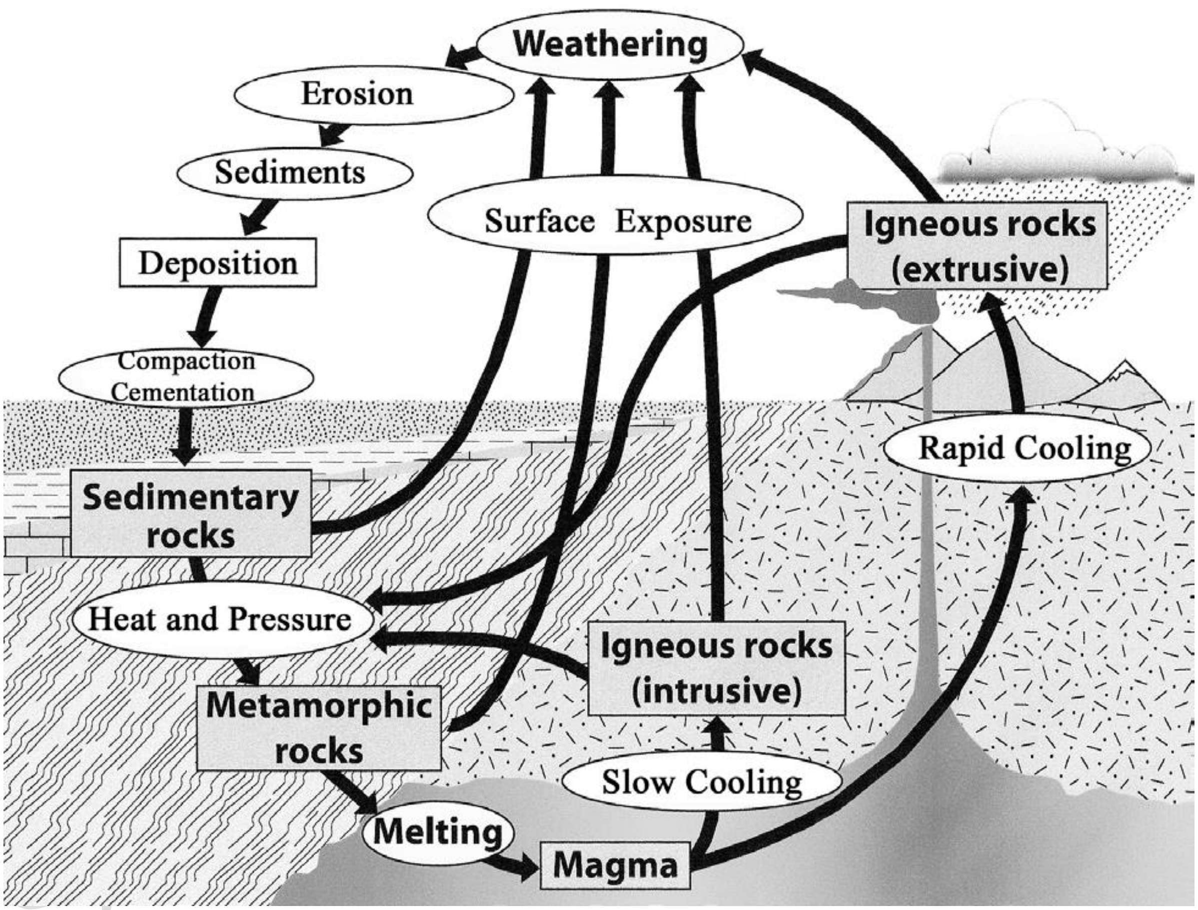
Metamorphic

- Forms when rocks are changed into different kinds of rocks by great heat and/or pressure – they are heated, squeezed, folded, or chemically changed by contact with hot fluids and/or tectonic forces.
- When heat and pressure reach the rock's melting point, it melts into magma.

Sedimentary

- Forms from the compaction and/or cementation of rock pieces, mineral grains, or shell fragments called sediments.
- Sediments are formed through the processes of weathering and erosion of rocks exposed at Earth's surface.
- Sedimentary rocks can also form from the chemical depositing of materials that were once dissolved in water.

The rock cycle is an ongoing process. The sample diagram illustrates the series of natural processes that can change rocks from one kind to another:



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Extended Knowledge

- Rocks are used for building and construction based on their properties.
- The rock cycle is an example of how Earth recycles itself.
- Heat and pressure results in metamorphic changes in minerals that, in turn, result in a rock being reclassified as a metamorphic rock.
- As heat and pressure increase, one type of metamorphic rock will transform into another type.

- When slow cooling magma is ejected before it has completely cools, the resulting igneous rock will have a mixture of macroscopic and microscopic mineral crystals (porphyritic texture: both intrusive and extrusive features)

Science and Engineering Practices
S.1A.2

Standard 8.E.5 The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.

Conceptual Understanding
8.E.5A All Earth processes are the result of energy flowing and matter cycling within and among Earth's systems. Because Earth's processes are dynamic and interactive in nature, the surface of Earth is constantly changing. Earth's hot interior is a main source of energy that drives the cycling and moving of materials. Plate tectonics is the unifying theory that explains the past and current crustal movements at the Earth's surface. This theory provides a framework for understanding geological history.

Performance Indicator
8.E.5A.3 Obtain and communicate information about the relative position, density, and composition of Earth's layers to describe the crust, mantle, and core.

Assessment Guidance
The objective of this indicator is to *obtain and communicate information about the relative position, density, and composition of Earth's layers (crust, mantle and core).* Therefore, the primary focus of assessment should be for students to *obtain and communicate information from a variety of sources (informational texts, primary and secondary sources, models, seismic data) to describe the relative position, composition, and density of Earth's interior structures.* This could include but is not limited to students comparing the layers of Earth based on relative position, density, and composition using diagrams and/or 3-D models.

In addition to *obtaining and communicating information*, students should be asked to *ask questions; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; and develop and use models.*

Previous and Future Knowledge
H.E.3 (Internal and external dynamics of Earth's geosphere)

Essential Knowledge
The Earth is approximately 4,000 miles (6,400 kilometers) from surface to center. Earth has layers that have specific conditions and composition.

Layer	Relative Position	Density	Composition
Crust	• Outermost layer • Oceanic crust is thinner than continental crust • Crust and top of mantle are called the lithosphere	• Least dense layer of all • Oceanic crust (basalt) is more dense than continental crust (granite)	• Solid rock made of mostly silicon and oxygen • Oceanic crust- basalt • Continental crust- granite
Mantle	• Middle layer • Thickest layer • Top portion called the asthenosphere	• Density increases with depth due to increasing pressure	• Hot softened rock • Contains iron and magnesium
Core	• Inner layer • Two parts- outer core and inner core	• Heaviest material • Most dense layer	• Mostly iron and nickel • Outer core- slow flowing liquid • Inner core- a spinning solid

Extended Knowledge
- Scientists have been able to identify the composition of inner and outer core based on the movement of seismic waves through the earth's layers.
- Scientists have been able to identify the composition of the mantle based on the movement of seismic waves through the earth's layers as well as materials ejected from volcanic activity. Most lava that erupts during volcanic activity is actually just melted crust and is not material from the mantle and/or the core.
- The reason that the inner core is solid, despite being at very high temperatures, is because of the weight of all of the other materials above it (crust, mantle, and outer core). The pressure of these layers keeps the inner core solid.
- The movement of the inner and outer core results in Earth's magnetic field.

Science and Engineering Practices
S.1A.8

Standard 8.E.5 The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.

Conceptual Understanding
8.E.5A All Earth processes are the result of energy flowing and matter cycling within and among Earth's systems. Because Earth's processes are dynamic and interactive in nature, the surface of Earth is constantly changing. Earth's hot interior is a main source of energy that drives the cycling and moving of materials. Plate tectonics is the unifying theory that explains the past and current crustal movements at the Earth's surface. This

theory provides a framework for understanding geological history.

Performance Indicator
8.E.5A.4 Construct explanations for how the theory of plate tectonics accounts for (1) the motion of lithospheric plates, (2) the geologic activities at plate boundaries, and (3) the changes in landform areas over geologic time.

Assessment Guidance
The objective of this indicator is to *construct explanations for how the theory of plate tectonics accounts for (1) the motion of lithospheric plates, (2) the geologic activities at plate boundaries, and (3) the changes in landform areas over geologic time.* Therefore the focus of assessment should be for students to use evidence from (1) the motion of lithospheric plates (2) geologic activities at plate boundaries and (3) changes in land form area over geologic time to support the theory of plate tectonics. This could include but is not limited to students constructing a cause-and-effect model of why the plates move, what type of motion takes places as plates collide, what changes result in the landforms of Earth; comparing the activities at plate boundaries, the shape/movement of landmasses over time; and classifying a plate boundary based on the motion of plates and/or landforms that result.

In addition to *constructing explanations*, students should be asked to *ask questions; plan and carry out investigations; engage in argument from evidence; obtain, evaluate and communicate information;* and *develop and use models.*

Previous and Future Knowledge
H.E.3 (Internal and external dynamics of Earth's geosphere)

Essential Knowledge
The theory of plate tectonics explains the past and current movements of the rocks at Earth's surface (lithospheric plates) and provides a framework for understanding its geological history. Plate movements are responsible for most continental and ocean floor features and for the distribution of most rocks and minerals within Earth's crust. Evidence that supports the theory of plate tectonics includes distribution of rock formation and fossils, shapes of existing continents, ocean floor features, and seismic and volcanic activity. This evidence shows how Earth's plates have moved great distances, collided, and spread apart throughout Earth's history
Motion of the Lithospheric Plates

- Plates float on the upper part of the mantle.
- Convection currents can cause the asthenosphere to flow slowly carrying with it the plates of the lithosphere.
- This movement of plates changes the sizes, shapes, and positions of Earth's continents and oceans.

Geologic Activities at Plate Boundaries
Divergent boundary—where two plates are moving apart

- Typically located along mid-ocean ridges although they can also be found on land
- new crust forms because magma pushes up and hardens in the rift zone between separating plates (seafloor spreading)
- earthquakes occur as the plates spread apart

Convergent boundary—where two plates come together and collide

- activity depends upon the types of crust that meet
- more dense oceanic plate slides under less dense continental plate or another oceanic plate forming a trench at the subduction zone where crust is melted and recycled
    - along these trenches, island arcs and volcanic arcs can be created

- two continental plates converge, both plates buckle and push up into mountain ranges or volcanoes
- earthquakes occur as the plates collide

Transform boundary—where two plates slide past each other

- crust is neither created nor destroyed;
- earthquakes occur frequently as plates slide past each other

Changes in Landform areas over Geologic Time

- Plates move at very slow rates, averaging about one to ten centimeters per year
- At one time in geologic history the continents were joined together in one large landmass that was called Pangaea.
- As the plates continued to move and split apart, oceans were formed, landmasses collided and split apart until the Earth's landmasses came to be in the positions they are now.
- Evidence of these landmass collisions and splits includes identical fossil formations found on separate continents, landform shapes and features, identical rock formations found on separate continents, and paleoclimate evidence (for example, evidence of warmer climates found in Antarctic fossils).
- Landmass changes can occur at hot spots within lithospheric plates. Volcanic activity occurs as magma rises and leaks through the crust.
- Earth's plates will continue to move.
- Landforms of Earth can be created or changed by volcanic eruptions and mountain-building forces.

Extended Knowledge

Tectonic forces

- Forces, or stresses, that cause rocks to break or move are:
  - Tension—forces that pull rocks apart
  - Compression—forces that push or squeeze rocks together
  - Shear*ing*—forces that cause rocks on either side of faults to push in opposite directions
- Forces or stresses (for example, *tension* and *compression*) on rocks in the lithosphere can cause them to bend and stretch.
  - This bending and stretching can produce mountain ranges.
  - If pressure is applied slowly, *folded mountains* form.
- If normal faults uplift a block of rock, a *fault-block mountain* forms.

Science and Engineering Practices

S.1A.6

Standard 8.E.5 The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.

Conceptual Understanding

8.E.5A All Earth processes are the result of energy flowing and matter cycling within and among Earth's systems. Because Earth's processes are dynamic and interactive in nature, the surface of Earth is constantly changing. Earth's hot interior is a main source of energy that drives the cycling and moving of materials. Plate tectonics is the unifying theory that explains the past and current crustal movements at the Earth's surface. This theory provides a framework for understanding geological history.

Performance Indicator

8.E.5A.5 Construct and analyze scientific arguments to support claims that plate tectonics accounts for (1) the distribution of fossils on different continents, (2) the occurrence of earthquakes, and (3) continental and ocean floor features (including mountains, volcanoes, faults and trenches).

Assessment Guidance

The objective of this indicator is to *construct and analyze scientific arguments to support claims* that plate tectonics accounts for (1) the distribution of fossils on different continents, (2) the occurrence of earthquakes, and (3) continental and ocean floor features (including mountains, volcanoes, faults and trenches). Therefore, the primary focus of assessment should be for students to *gather data from various sources to engage in argumentation supporting claims* for how plate tectonics has resulted in the (1) the distribution of fossils on different continents, (2) the occurrence of earthquakes, and (3) continental and ocean floor features. This could include but is not limited to students interpreting geologic maps for the location of fossils, continental and ocean floor features, and data on the frequency and distribution of earthquakes and volcanoes as evidence to support claims about the theory of plate tectonic.

In addition to *constructing scientific arguments to support claims*, students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; construct explanations; obtain, evaluate and communicate information;* and *develop and use models*.

Previous and Future Knowledge

H.E.3 (Internal and external dynamics of Earth's geosphere)

Essential Knowledge

There is a variety of evidence that supports the claims that plate tectonics accounts for (1) the distribution of fossils on different continents, (2) the occurrence of earthquakes, and (3) continental and ocean floor features (including mountains, volcanoes, faults and trenches).

- The continents fit together almost like puzzle pieces forming Pangaea (one super-continent).
- Fossils on different continents are similar to fossils on continents that were once connected. When the continents split, different life forms developed.
- Most continental and oceanic floor features are the result of geological activity and earthquakes along plate boundaries. The exact patterns depend on whether the plates are converging (being pushed together) to create mountains or deep ocean trenches, (diverging) being pulled apart to form new ocean floor at mid-ocean ridges, or sliding past each other along surface faults.
- Most distributions of rocks within Earth's crust, including minerals, fossil fuels, and energy resources, are a direct result of the history of plate motions and collisions and the corresponding changes in the configurations of the continents and ocean basins.
- This history is still being written. Continents are continually being shaped and reshaped by competing constructive and destructive geological processes.

Example: North America has gradually grown in size over the past 4 billion years through a complex set of interactions with other continents, including the addition of many new crustal segments.

Extended Knowledge

- During the time of Pangaea most of the dry land on Earth was joined into one huge landmass that covered nearly a third of the planet's surface. The giant ocean that surrounded the continent is known as Panthalassa.
- Pangaea existed during the Permian and Triassic geological time periods, which were times of great change.

- Most distributions of rocks within Earth's crust, including minerals, fossil fuels, and energy resources, are a direct result of the history of plate motions and collisions and the corresponding changes in the configurations of the continents and ocean basins.
- North America has gradually grown in size over the past 4 billion years through a complex set of interactions with other continents, including the addition of many new crustal segments.

Science and Engineering Practices
S.1A.7

Standard 8.E.5 The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.

Conceptual Understanding
8.E.5B Natural processes can cause sudden or gradual changes to Earth's systems. Some may adversely affect humans such as volcanic eruptions or earthquakes. Mapping the history of natural hazards in a region, combined with an understanding of related geological forces can help forecast the locations and likelihoods of future events.

Performance Indicator
8.E.5B.1 Analyze and interpret data to describe patterns in the location of volcanoes and earthquakes related to tectonic plate boundaries, interactions, and hot spots.

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* to describe patterns in the location of volcanoes and earthquakes in relation to tectonic plate boundaries, interactions, and hot spots. Therefore, the primary focus of assessment should be for students to *analyze and interpret data from visual images and data collected from investigations and informational text to reveal patterns and construct meaning* regarding the relationship between the location of volcanoes and earthquakes and plate boundaries, interactions, and hot spots. This could include but is not limited to (1) plotting the location of earthquakes and volcanoes to identify patterns and (2) interpreting visual images from remote sensing technologies of the location of seismic activity over periods of time to determine locations of frequent seismic (earthquake and volcanic) activity.

In addition to *analyze and interpret data*, students should be asked to *ask questions; plan and carry out investigations; engage in argument from evidence; construct explanations; develop and use models;* and *obtain, evaluate, and communicate information.*

Previous and Future Knowledge
H.E.3 (Internal and external dynamics of Earth's geosphere)

Essential Knowledge
Scientists study and record seismic data and volcanic activity in order to support the theory of plate tectonics. The evidence proves that there is a distinct relationship between seismic activity, volcanic activity, and the lithospheric plate boundaries.
Seismic Data and Plate Tectonics:
- The interaction along plate boundaries results in an increased frequency of earthquakes at those locations. Additionally, stronger earthquakes are more likely to occur along active plate boundaries.
- Strong earthquakes are more common at transform and convergent plate boundaries.

- The San Andreas fault in California is an example of an active transform plate boundary.

Volcanic Activity and Plate Tectonics:

- The interaction of plate boundaries results in an increased frequency of volcanic activity at these locations.
- Volcanoes occur at convergent plate boundaries where subducting oceanic crust is melted. This magma rises through the crust to form volcanoes and volcanic island arcs.
- Volcanoes occur at divergent plate boundaries where upwelling magma pushes between plates (rift zones) as the plates move apart.

- The Pacific Ring of fire is a region of high volcanic and seismic activity that surrounds the majority of the Pacific Ocean Basin. The Pacific Ring of Fire is made up of converging plate boundaries that border the Pacific Ocean basin. Scientists use volcanic activity data from this area to show the relationship between volcanic activity and lithospheric plate motion.

Hot Spots and Plate Tectonics:

A volcanic *hotspot* is an area in the mantle from which heat rises in the form of a thermal plume from deep within the Earth. Higher heat and lower pressure at the base of the lithosphere melts rock and forms magma. The magma rises through the cracks in the lithosphere and erupts to form volcanoes. As the tectonic plates continue to move over a stationary hotspot, the volcanoes break away and move along with the plate allowing new volcanoes to form in their place. This plate tectonic movement over a hotspot results in chains of volcanoes, such as the Hawaiian Islands.

Extended Knowledge

- At a hot spot, higher heat and lower pressure at the base of the lithosphere melts rock and forms magma. The magma rises through the cracks in the lithosphere and erupts to form volcanoes.
- Students can trace the Hawaiian island chain and the Emperor Sea Mounts to not only show the stationary nature of the hot spot versus the movement of the Pacific plate, but can also see where the plate itself changed the direction it is moving.

Science and Engineering Practices

S.1A.4

Standard 8.E.5 The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.

Conceptual Understanding

8.E.5B Natural processes can cause sudden or gradual changes to Earth’s systems. Some may adversely affect humans such as volcanic eruptions or earthquakes. Mapping the history of natural hazards in a region, combined with an understanding of related geological forces can help forecast the locations and likelihoods of future events.

Performance Indicator

8.E.5B.2 Construct explanations of how forces inside Earth result in earthquakes and volcanoes.

Assessment Guidance

The objective of this indicator is to *construct explanations* of how forces inside Earth result in earthquakes and volcanoes. Therefore, the primary focus of assessment should be for students to *use evidence from a variety of sources to describe* the cause and effect relationship between lithospheric plate motion and seismic and volcanic activity. This could include but is not limited to students creating models and simulations of how the movement of lithospheric plates results in seismic and volcanic activity, comparing data and visual images of seismic and volcanic activity and being asked to explain, using evidence from the diagrams, how forces within the Earth result in earthquakes and volcanoes.

In addition to *construct explanations*, students should be asked to *ask questions; plan and carry out investigations; engage in argument from evidence; obtain, evaluate and communicate information;* and *develop and use models.*

Previous and Future Knowledge
H.E.3(Internal and external dynamics of Earth's geosphere)

Essential Knowledge
Convection currents in the mantle result in the movement of lithospheric plates. The motion and interactions of the plates can create patterns in the location of volcanoes and earthquakes that result along the plate boundaries.

The resulting activity that happens along the plate boundaries depends on the type of plate boundary being created (divergent, convergent, and transform) and the forces associated with those boundaries (compression, tension, and shearing). For example:
Lithospheric Plate Motion and Seismic Activity:

- Earthquakes occur along plate boundaries where tectonic forces result in the formation of faults and the buildup of pressure. When this built up pressure is released, an earthquake results along this fault line.
- Earthquakes can also occur along faults
    - Scientists can specifically identify the type of boundary and fault that occurs along the edges of the plates by examining plate boundary maps. Scientists can also use seismic data to understand the ways in which the plates are moving and the relationship between seismic activity and lithospheric plate motion

Lithospheric Plate Motion and Volcanic Activity:

- There is scientific data supporting abundant volcanism occurrences at divergent and convergent plate boundaries and a lack of volcanism associated with transform plate boundaries.
    - Volcanic activity at divergent plate boundaries occurs as the plates pull apart which allows magma to fill the rift zone between the separating plates.
    - Volcanic activity at convergent plate boundaries occurs as the two plates converge on one another. The leading edge of the subducted plate melts and rises through the overlying crust resulting in the formation of a volcanic chain of mountains. The most volcanically active belt on Earth is known as the *Ring of Fire*, a region of volcanic activity that happens at subduction zones surrounding the Pacific Ocean.
    - Volcanic eruptions are constructive in that they add new rock to existing land and form new islands. Volcanic eruptions can be destructive when an eruption is explosive and changes the landscape of and around the volcano.
    - Magma that reaches Earth's surface is known as *lava*.

Extended Knowledge

- The specific types of volcanism that happens at divergent and convergent plate boundaries are called spreading center volcanism and subduction zone volcanism
- Intraplate volcanism is another term to describe the presence of volcanic activity over hot spots
- Specific surface features created from lithospheric plate motion include the Mid-Atlantic Ridge, Mariana trench, and the Aleutian trench

Science and Engineering Practices
S.1A.6

Standard 8.E.5 The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.

Conceptual Understanding
8.E.5B Natural processes can cause sudden or gradual changes to Earth's systems. Some may adversely affect humans such as volcanic eruptions or earthquakes. Mapping the history of natural hazards in a region, combined with an understanding of related geological forces can help forecast the locations and likelihoods of future events.

Performance Indicator
8.E.5B.3 Define problems that may be caused by a catastrophic event resulting from plate movements and design possible devices or solutions to minimize the effects of that event on Earth's surface and/or human structures.

Assessment Guidance
The objective of this indicator is to *define problems* that may be caused by catastrophic events resulting from plate movements and *design possible solutions* to minimize the effects of those events on Earth's surface and/or human structures. Therefore, the primary focus of assessment should be for students to *(1) ask questions to identify problems or needs, (2) ask questions about the criteria and constraints of the devices or solutions, (3) generate and communicate ideas for possible devices or solutions, (4) build and test devices or solutions, (5) determine if the devices or solutions solved the problem, and (6) communicate the results.* This could include but is not limited to students defining problems that may result from seismic and volcanic activity, using tools and/or materials to design and/or build a device that solves a specific problem related to the local and global effects of these activities, and communicating how these solutions minimize the effects of earthquakes and volcanic activity in a specific location.

In addition to *define problems* and *design possible solutions*, students should be asked to *develop and use models; plan and carry out tests; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence*; and *obtain, evaluate, and communicate information.*

Previous and Future Knowledge
H.E.3(Internal and external dynamics of Earth's geosphere)

Essential Knowledge
Most earthquakes and volcanic eruptions do not strike randomly but occur in specific areas such as along plate boundaries. For example, the Ring of Fire where the Pacific Plate interacts with many surrounding plates, is known as one of the most seismically and volcanically active zones in the world.

- Earthquakes and People:
    - Many population centers are located near active fault zones and/or active plate boundaries, such as the San Andreas Fault. Millions of people in these population centers have suffered personal and economic losses due to volcanic and earthquake activity.
- Defining problems associated with earthquakes:
    - There is evidence to support the idea that tectonic activity contributed to the demise of ancient civilizations. Based on the locations of current population centers, scientists have developed

models that show that populations today may be just as vulnerable to the aftereffects of powerful earthquakes.
    - When exposed to sudden lateral forces produced by seismic waves buildings and bridges can fail completely and collapse, crushing the people in and around them.
    - Modern population centers tend to be more densely packed with large numbers of tall buildings. The complex infra-structure of modern cities also poses a danger in case of a major earthquake.
    - Over the past few decades, architects and engineers have developed a number of innovative technologies to ensure houses, multi-dwelling units, and skyscrapers bend instead of break. Making these buildings more pliable, less brittle, and better able to move with the earthquake waves has made it possible for inhabitants to survive extremely destructive earthquakes.
- <u>Defining problems associated with Volcanoes</u>:
    - Most of the world's active above-sea volcanoes are located near convergent plate boundaries, an area of subduction. Subduction-zone volcanoes typically erupt with an extremely explosive force. There are many large population centers that are within areas that may be affected by explosive volcanic eruptions. These powerful eruptions can affect people in many different ways:
        - *Local effects* – personal property damage, personal injuries or possible death, destruction of urban and suburban areas, disruption of local water supplies, contamination of food sources, landslides, and lack of breathable air
        - *Global effects* – changes in weather and climate, aviation safety hazards, tsunamis if volcanic activity is under or near oceans, seismic activity in accompaniment with volcanic activity, and production of acid rain
- <u>Minimization Efforts of Volcanic Effects</u>:
    - The pathway of an eruption is difficult to predict so most of the minimization efforts are focused on monitoring volcanoes for increased activity. This provides enough warning for people in the potentially affected areas to be evacuated.
    - Scientists suggest the following for structures where volcanic activity may occur:
        - houses should be constructed in a manner that will allow for all vents to be closed
        - windows and doors should be properly insulated

Extended Knowledge

The following major earthquakes and volcanic eruptions may be studied in further detail:
- <u>*Volcanic Eruptions of Interest*</u>:
    - Mount Pinatubo in Philippines (1991-1996)
    - Rabaul in Papua New Guinea (1994)
    - Lake Nyos in Cameroon (1986)
    - Nevado del Ruiz in Columbia (1985)
    - El Chichon in Mexico (1982)
    - Mount St. Helens (1980)
    - Mount Tambora (1815) that resulted in the year without a summer
- <u>*Earthquakes of Interest*</u>:
    - Great San Francisco Earthquake – 1906 (8.3 magnitude)
    - Loma Prieta Earthquake – 1989 (7.1 magnitude)
    - Kobe, Japan Earthquake – 1995 (7.2 magnitude)
    - Northridge Earthquake – 1994 (6.6 magnitude)
    - Charleston, South Carolina Earthquake – 1886 (7.0 magnitude)
    - Haiti Earthquake – 2010 (7.0 magnitude)
    - Indian Ocean Earthquake (9.0 magnitude)

- Further exploration of the “temblor thwarting technologies” for earthquake prevention and sustaining buildings may also studied
- Students can also research the locations of, and history of, super volcanoes. From this information, students can explore the past effects of these types of eruptions and extrapolate the potential effects of a modern eruption of a super volcano.

Science and Engineering Practices
S.1B.1

Standard 8.E.5 The student will demonstrate an understanding of the processes that alter the structure of Earth and provide resources for life on the planet.

Conceptual Understanding
8.E.5C Humans depend upon many Earth resources – some renewable over human lifetimes and some nonrenewable or irreplaceable. Resources are distributed unevenly around the planet as a result of past geological processes.

Performance Indicator
8E.5C.1 Obtain and communicate information regarding the physical and chemical properties of minerals, ores, and fossil fuels to describe their importance as Earth resources.

Assessment Guidance
The objective of this indicator is to *obtain and communicate information* regarding the physical and chemical properties of minerals, ores, and fossil fuels to describe their importance as Earth resources. Therefore, the primary focus of assessment should be for students to *obtain, evaluate, and communicate information from a variety of sources (informational texts, observations, data collected or discussions) to describe how the physical and chemical properties of* minerals, ores, and fossil fuels make them important Earth resources. This could include but is not limited to students conducting research and creating multimedia presentations on the properties and uses of minerals, ores, and fossil fuels and engaging in argumentation from evidence from informational text and scientific investigation on the benefits, usefulness, and conservation of minerals, ores, and fossil fuels.

In addition to *obtaining and communicating information*, students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models*; and *construct devices or define solutions.*

Previous and Future Knowledge
H.E.3 (Internal and external dynamics of Earth’s geosphere)

Essential Knowledge
Earth’s resources (minerals, ores, and fossil fuels) have properties that make them important and useful. Properties that determine the usefulness of an ore or mineral may be identified using a chart, diagram, or dichotomous key. Two types of properties used to determine the usefulness and value of a resource include:
- *Physical properties*: characteristics that can be observed of measured without changing the matter’s identity

- *Chemical properties*: characteristics that describe matter based on its ability to change into new materials that have different properties
- Three common Earth resources that have importance based on their properties are:
    - *Minerals*: natural, solid materials found on Earth that are the building blocks of rock
        - Each mineral has a certain chemical makeup and set of properties that determine their use and value such as hardness, luster, color, texture, cleavage/fracture (the way it breaks), flammability, reactivity to acids, and density
        - One such valuable mineral is gypsum. It is used in the production of cement.
    - *Ores*: minerals that are mined because they contain useful metals or nonmetals
        - One such valuable ore is bauxite. It is a primary source of aluminum.
    - *Fossil fuels*: natural fuels that come from the remains of living things
        - Fuels give off energy when they are burned
        - One such valuable fossil fuel is natural gas. It is a cleaner-burning fuel source.

Extended Knowledge
Minerals can be classified and identified using their physical and chemical properties. Some minerals have specific identifying features that are key indicators used to identify the mineral. Using mineral identification kits to test a mineral's hardness, observe its luster, reactivity to acid, and cleavage/fracture (the way it breaks) to identify a mineral is an important classification strategy.
There are positive and negative consequences of the removal and use of these non-renewable resources.

Science and Engineering Practices
S.1A.8

Standard 8.E.6 The student will demonstrate an understanding of Earth's geologic history and its diversity of life over time.

Conceptual Understanding
8.E.6A Conceptual Understanding: The geologic time scale interpreted from rock strata provides a way to organize major historical events in Earth's history. Analysis of rock strata and the fossil record, which documents the existence, diversity, extinction, and change of many life forms throughout history, provide only relative dates, not an absolute scale. Changes in life forms are shaped by Earth's varying geological conditions.

Performance Indicator
8.E.6A.1 Develop and use models to organize Earth's history (including era, period, and epoch) according to the geologic time scale using evidence from rock layers.

Assessment Guidance
The objective of this indicator is to *develop and use models* to organize Earth's history (including eras, periods, and epochs) according to the geologic time scale using evidence from rock layers. Therefore, the primary focus of this assessment should be for students to *construct drawings/diagrams and models that represent* how Earth's history has been divided and organized on the geologic time scale based on evidence from the geologic record. This should include but is not limited to students using events from key events from Earth's geologic record to create a model that subdivides Earth's history into eras, periods, and epochs.

In addition to *developing and using models*, students should be asked to: *ask questions; analyze and interpret data; use mathematical and computational thinking; engage in argument from evidence; construct explanations;* and *obtain, evaluate, and communicate information*.

Previous and Future Knowledge

H.E.4 (Earth's conditions over geologic time and the diversity of organisms)

Essential Knowledge

The geologic time scale is a record of the major events and diversity of life forms present in Earth's history. The geologic time scale began when Earth was formed and goes on until the present. It divides Earth's long history into units of time.

- Precambrian is the name given to the earliest span of time in Earth history.
- Geologists divide the time between Precambrian and the present into three long units called eras (Paleozoic, Mesozoic, Cenozoic).
  - eras are divided into periods
  - periods can be further divided into epochs
  - these subdivisions are based on large scale events in Earth's history that are identified in the fossil record and rock layers
- At the end of each era a major mass extinction occurred, many kinds of organisms died out, although there were other extinctions going on during each period of geologic time.

The layers of rock on Earth serve as evidence when identifying the geologic time scale. Using the fossil record, paleontologists have created a picture of the different types of common organisms in each geologic period.

Paleozoic Era

- Began with the early invertebrates, such as trilobites and brachiopods; continued to develop early vertebrate fish, then arachnids and insects; later came the first amphibians, and near the era's end the reptiles became dominant.
- Early land plants included simple mosses, ferns, and then cone-bearing plants.
- By the end of the era, seed plants were common.
- The mass extinction that ended the era caused most marine invertebrates as well as amphibians to disappear.
- A major geologic event of the Paleozoic was the formation of the super continent of Pangaea.

Mesozoic Era

- Reptiles were the dominant animals of this era, including the various dinosaurs.
- Small mammals and birds also appeared.
- Toward the end of the era, flowering plants appeared and the kinds of mammals increased.
- The mass extinction that ended the era caused the dinosaurs to become extinct.
- A major geologic event of the Mesozoic was the break-up of the super continent of Pangaea into several large continents.

Cenozoic Era

- New mammals appeared while others became extinct.
- The diversity of life forms increased.
- Flowering plants became most common.
- Humans are also part of the most recent period of this era.
- Present day Earth is in this era.
- A major geologic event of the Cenozoic is the further splitting and moving of continents to their current positions.

Extended Knowledge

- Cambrian being the first period is important. The Cambrian Explosion was a time where there was a relatively rapid appearance of most major animal phyla as evidenced by the fossil record.
- With a more complete fossil record available, the periods of the Cenozoic era are subdivided further into epochs.
- Present day Earth is in the Quaternary period in the Holocene epoch.
- About 95 percent of marine species and 70 percent of land animals were wiped out after the Permian mass extinction. It is suspected that periods of rapid global warming and cooling that happened so quickly most organisms were not able to adjust. Students can research the effect that this extinction had on the evolution of species.
- Students can research additional geologic events, such as periods of increased volcanism and the effect on world-wide climate, mountain formation, climate changes and ice ages, large scale impacts of asteroids and meteorites, and the effect of rising and falling sea levels on early human migrations.

Science and Engineering Practices
S.1A.2

Standard 8.E.6 The student will demonstrate an understanding of Earth's geologic history and its diversity of life over time.

Conceptual Understanding
8.E.6A Conceptual Understanding: The geologic time scale interpreted from rock strata provides a way to organize major historical events in Earth's history. Analysis of rock strata and the fossil record, which documents the existence, diversity, extinction, and change of many life forms throughout history, provide only relative dates, not an absolute scale. Changes in life forms are shaped by Earth's varying geological conditions.

Performance Indicator
8.E.6A.2 Analyze and interpret data from index fossil records and the ordering of rock layers to infer the relative age of rocks and fossils.

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* from the fossil record and the ordering of rock layers to infer the relative age of rocks and fossils. Therefore the primary focus of this assessment should be for students *to analyze and interpret data from informational texts and data collected from investigations to reveal patterns and construct meaning that can be used to infer* the relative age of rocks and fossils. This could include, but is not limited to students analyzing the ordering of rock layers from diagrams and interpreting data from those diagrams in reference to the age of index fossils in order to determine the relative age of rocks and fossils.

In addition to *analyze and interpret data*, students should be asked to: *ask questions; use mathematical and computational thinking; engage in argument from evidence; construct explanations; develop and use models;* and *obtain, evaluate, and communicate information*.

Previous and Future Knowledge
H.E.4 (Earth's conditions over geologic time and the diversity of organisms)

Essential Understanding
Relative age means the age of one object compared to the age of another object. Relative age does not tell the exact age of an object. The relative age of rocks and fossils can be determined using two basic methods: ordering of rock layers and index fossils:

- Ordering of Rock Layers
  - Scientists read the rock layers knowing that each layer is deposited on top of other layers.
  - The law of superposition states that each rock layer is older than the one above it. So, the relative age of the rock or fossil in the rock is older if it is farther down in the rock layers.
  - Relative dating can be used only when the rock layers have been preserved in their original sequence.
- Index Fossils
  - Certain fossils, called index fossils, can be used to help find the relative age of rock layers. To be an index fossil –
    - an organism must have lived only during a short part of Earth's history;
    - many fossils of the organism must be found in rock layers;
    - the fossil must be found over a wide area of Earth;
    - the organism must be unique.
  - The shorter time period a species lived, the better an index it is.
  - Fossils that are found in many rock layers, therefore living long periods of time, do not qualify as index fossils.

Extended Knowledge

- A key example of an organism used as an index fossil are trilobites, a group of hard-shelled animals whose body had three sections, lived in shallow seas, and became extinct about 245 million years ago. Therefore, if a trilobite is found in a particular rock layer, it can be compared with trilobites from other layers to estimate the age of the layer in which it was found.
- Complex layering due to intrusions and extrusions, faults, or unconformities can make dating rocks and fossils challenging.
- Radioactive element decay can also be used to tell the age of fossils and rocks.

Science and Engineering Practices
S.1A.4

Standard 8.E.6 The student will demonstrate an understanding of Earth's geologic history and its diversity of life over time.

Conceptual Understanding
8.E.6A Conceptual Understanding: The geologic time scale interpreted from rock strata provides a way to organize major historical events in Earth's history. Analysis of rock strata and the fossil record, which documents the existence, diversity, extinction, and change of many life forms throughout history, provide only relative dates, not an absolute scale. Changes in life forms are shaped by Earth's varying geological conditions.

Performance Indicator
8.E.6A.3 Construct explanations from evidence for how catastrophic events (including volcanic activities, earthquakes, climatic changes, and the impact of an asteroid/comet) may have affected the conditions on Earth and the diversity of its life forms.

Assessment Guidance
The objective of this indicator is to *construct explanations* of how catastrophic events in Earth's history may have affected the conditions on Earth and the diversity of its life forms. Therefore the focus of this assessment should be for students to *construct explanations of phenomena using (1) primary or secondary scientific evidence and models (2) conclusions from scientific investigations (3) predictions based on observations and measurements or (4) data communicated in graphs, tables, or diagrams to explain* how the catastrophic events that have taken place in Earth's history have affected the conditions on Earth and the diversity of its life forms. This could include, but is not limited to students exploring the history of volcanic activity, earthquakes, climate change and impacts of asteroids and comets throughout Earth's history in order to explain how these events may have affected the conditions on Earth and the diversity of its life forms.

In addition to *construct explanations*, students should be asked to: *ask questions; engage in argument from evidence; obtain, evaluate and communicate information; develop and use models*, and *construct devices or design solutions*.

Previous and Future Knowledge
5.E.3 (Natural processes and human activities affect the features of Earth's landforms and oceans)
H.E.4 (Earth's conditions over geologic time and the diversity of organisms)

Essential Knowledge
There is evidence to support the changes in life forms over Earth's history (additions and extinctions) are often accompanied by changes in environmental conditions on Earth. Impacts, climate changes, and volcanism can produce sudden and rapid changes to environmental conditions. Many organisms cannot adapt to these sudden and rapid changes resulting in the extinction of those species. When these events are global in nature then mass extinctions can occur.
Impact of an asteroid or comet

- Earth's atmosphere protects the planet from many of the meteors that enter it, resulting in their burning up before striking the surface.
- There is evidence to support the claim that numerous impacts have occurred throughout Earth' history. These impacts have had both local and large-scale effects on the environment and biodiversity.
- There is evidence to support that at the end of the Mesozoic Era a large asteroid or comet impacted with Earth. This impact caused dust and smoke to rise into the atmosphere and cause climatic changes, as well as the dying of many forms of plant life and animals that depended on those plants for food.
    - At the end of the Mesozoic Era, when reptiles, early birds and mammals thrived, many groups of animals disappeared suddenly.
    - A major life form that disappeared at this time was the dinosaur.

Climatic changes
Earth's environments have many different climates even today. Climate is an ever-changing condition on Earth.

- Earliest life forms were influenced by the climates produced by the forming atmosphere and oceans of Earth.
- Life on land developed and flourished in the tropical climates and warm shallow seas during the Paleozoic Era. Throughout this era as different land environments formed and sea levels changed, new life forms developed. Other life forms that could not adapt or find suitable conditions, especially many marine species, disappeared.
- During the Mesozoic era, many climate changes occurred due to plate tectonics and the movement of landmasses. Plants and animals that survived through this time had structures and systems that allowed for greater adaptations, such as seed coverings for plant seeds and protective body coverings or constant internal temperature for animals.

- During the present Cenozoic era, climate conditions continue to change. Major ice ages caused the climate to become much cooler as ice sheets and glaciers covered many areas of Earth. Many mountain ranges formed causing climate differences due to elevation and due to location near those ranges.

Volcanic activity

- From the earliest days while Earth was forming to present day, volcanic activity has been part of the nature of this changing planet.
    - During the Precambrian time volcanic activity was one of the most natural events, but lava flows, ash clouds in the atmosphere, and heat made conditions for life forms extremely difficult. Those simple life forms often did not survive these conditions.
    - As continents collided and mountains built up due to plate tectonics, volcanoes also formed. Volcanic activity continued to be common in the Paleozoic era.
    - During the rapid movement of plates in the Mesozoic era, collisions and subduction produced extensive volcanic activity around plate boundaries. Plate boundaries are still the location of much of Earth's volcanic activity.
    - Very explosive volcanic activity can send ash and dust high into the atmosphere where it is carried great distances around the Earth. The Sun can be blocked for long periods of time. This violent type of activity can disrupt many of Earth's processes and ultimately the life forms that depend on those processes.

Extended Knowledge

- Paleoseismology is the study of the timing, location, and size of prehistoric earthquakes.
- A huge crater off Mexico's Yucatán Peninsula is dated to about 65 million years ago, coinciding with the Cretaceous extinction.
- Massive floods of lava erupting from the central Atlantic magmatic province about 200 million years ago may explain the Triassic-Jurassic extinction.
- More than 90 percent of all species perished during the Permian-Triassic extinction event about 250 million years ago.
- Ordovician-Silurian extinction, about 440 million years ago, involved massive glaciations that locked up much of the world's water as ice

Science and Engineering Practices

S.1A.6

Standard 8.E.6 The student will demonstrate an understanding of Earth's geologic history and its diversity of life over time.

Conceptual Understanding

8.E.6A Conceptual Understanding: The geologic time scale interpreted from rock strata provides a way to organize major historical events in Earth's history. Analysis of rock strata and the fossil record, which documents the existence, diversity, extinction, and change of many life forms throughout history, provide only relative dates, not an absolute scale. Changes in life forms are shaped by Earth's varying geological conditions.

Performance Indicator:

8.E.6A.4 Construct and analyze scientific arguments to support claims that different types of fossils provide evidence of (1) the diversity of life that has been present on Earth, (2) relationships between past and existing life forms, and (3) environmental changes that have occurred during Earth's history.

Assessment Guidance
The objective of this indicator is to *construct and analyze scientific arguments to support claims* that different types of fossils provide evidence of (1) the diversity of life that has been present on Earth (2) relationships between past and existing life forms and (3) environmental changes that have occurred during Earth's history. Therefore, the primary focus of this assessment should be for students to *construct scientific arguments to support claims or explanations using evidence from observations, data, or informational texts* that different types of fossils provide evidence of the diversity of life on Earth, the relationships between past and present life forms, and environmental changes that have occurred in Earth's history. This could include, but is not limited to students observing and analyzing pictures of past and present-day life forms in order to determine if a relationship exists between the two and make claims and provide evidence as to why the relationship may exist.

In addition to *construct and analyze scientific arguments to support claims*, students should be asked to: *ask questions; plan and carry out investigations; analyze and interpret data; construct explanations;* and *obtain, evaluate, and communicate information*.

Previous and Future Knowledge
H.E.4 (Earth's conditions over geologic time and the diversity of organisms)

Essential Knowledge
Fossils are mineral replacements, preserved remains, or traces of organisms that lived in the past. The collection of fossils and their placement in chronological order is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms and environmental changes throughout the history of life on Earth.

- Thousands of layers of sedimentary rock not only provide evidence of the history of Earth itself but also of changes in organisms whose fossil remains have been found in those layers.
    - Erosion and weathering of sedimentary rock layers can cause the destruction of fossils and result in gaps in the fossil record.
- Certain environmental conditions favor certain fossil formations. Therefore, the type of fossils found in an area can explain the environmental changes that have occurred.
    - The rapid burial of organisms, which is more likely to occur in marine environments, results in a greater likelihood that the remains of marine organisms will be preserved. Flash floods and volcanic ash falls help preserve land organisms.
- Certain fossilized organisms could only live in specific environments or under particular climate conditions.
- Extinction of life forms as well as how and when new life forms appeared is part of the fossil record.
- Fossils can show structural similarities and differences in organisms over time revealing the vast diversity of life forms that have and continue to exist on Earth.
- Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record enable the understanding of the diversity of life that has been present on Earth.
- Comparisons between living organisms and fossils also allow scientists to make inferences about the lines of descent.

Extended Knowledge
- Mold fossil – forms when sediments bury an organism and the sediments change into rock; the organism decays leaving a cavity in the shape of the organism.
- Cast fossil – forms when a mold is filled with sand or mud that hardens into the shape of the organism.

- Petrified fossil (permineralized fossil) – forms when minerals soak into the buried remains, replacing the remains, and changing them into rock.
- Preserved fossil – forms when entire organisms or parts of organisms are prevented from decaying by being trapped in rock, ice, tar, or amber.
- Carbonized fossil – forms when organisms or parts, like leaves, stems, flowers, fish, are pressed between layers of soft mud or clay that hardens squeezing almost all the decaying organism away leaving the carbon imprint in the rock.
- Trace fossil – forms when the mud or sand hardens to stone where a footprint, trail, or burrow of an organism was left behind.

Science and Engineering Practices
S.1A.7

Standard 8.E.6 The student will demonstrate an understanding of Earth's geologic history and its diversity of life over time.

Conceptual Understanding
8.E.6A Conceptual Understanding: The geologic time scale interpreted from rock strata provides a way to organize major historical events in Earth's history. Analysis of rock strata and the fossil record, which documents the existence, diversity, extinction, and change of many life forms throughout history, provide only relative dates, not an absolute scale. Changes in life forms are shaped by Earth's varying geological conditions.

Performance Indicator
8.E.6A.5 Construct explanations for why most individual organisms, as well as some entire taxonomic groups of organisms, that lived in the past were never fossilized.
Assessment Guidance
The objective of this indicator is to *construct explanations* for why most individual organisms, as well as some entire taxonomic groups of organisms that have lived in the past were never fossilized. Therefore, the focus of this assessment should be for students to *construct explanations from primary and secondary sources and investigations* as to why most individual organisms, and some entire taxonomic groups, that lived in the past were never fossilized. This could include but is not limited to students comparing the different ways organisms have been preserved throughout Earth's history and use evidence from those comparisons to explain why some organisms were unable to be preserved.

In addition to *construct explanations*, students should be asked to: *ask questions, engage in argument from evidence; obtain, evaluate, and communicate information;* and *develop and use models.*

Previous and Future Knowledge
H.E.4 (Earth's conditions over geologic time and the diversity of organisms)

Essential Knowledge
Because of the conditions necessary for their preservation, not all types of organisms that existed in the past have left fossils that can be retrieved.
- In order for a fossil to form, the organism's remains must not be significantly disturbed by a scavenger/decomposer or destroyed by erosion and other natural forces. Therefore, organisms or parts of organisms that make up fossils are most likely buried quickly and deeply.

    - Example: woolly mammoth found in ice, insects found in amber, animals found in peat bogs, mass burials from flash floods or volcanic ash falls
- Soft body parts, such as skin, muscle, fat, and internal organs, deteriorate rapidly and leave no trace. Casts of such tissues are rarely found. Similarly, organisms that are soft-bodied creatures, like jellyfish, are very uncommon fossils while hard body parts (such as teeth and shells) fossilize easier.
- Molds can be made of organisms. However, the organism must be buried in sediment after which its tissues dissolve and are replaced by dissolved minerals which make it a solid. Without the correct minerals this process cannot take place.
- The fact that extremely few living things are preserved long enough after death to become fossils makes the large collections of fossils in the museums of the world quite remarkable

Extended Knowledge
- Taphonomy is the study of the conditions under which plants, animals, and other organisms become altered after death and sometimes preserved as fossils.
- With molds, sometimes the rock has the appearance of the organism. Sometimes, all traces of the organism are lost but an external mold is formed around the body and is preserved. Sometimes an internal mold forms when material is precipitated inside an organism (ex: a marine shell or the hollow stem of a plant).

Science and Engineering Practices
S.1A.6

Standard 8.E.6 The student will demonstrate an understanding of Earth's geologic history and its diversity of life over time.

Conceptual Understanding
8.E.6B Adaptation by natural selection acting over generations is one important process by which species change in response to changes in environmental conditions. The resources of biological communities can be used within sustainable limits, but if the ecosystem becomes unbalanced in ways that prevent the sustainable use of resources, then ecosystem degradation and species extinction can occur.

Performance Indicator
8.E.6B.1 Construct explanations for how biological adaptations and genetic variations of traits in a population enhance the probability of survival in a particular environment.

Assessment Guidance
The objective of this indicator is to *construct explanations* of how biological adaptations and genetic variations of traits in a population enhance the probability of survival in a particular environment. Therefore the focus of assessment should be for students to *construct explanations using evidence from scientific investigations, visual representations, and informational text* to explain how adaptations due to natural selection and genetic variation enhance the survivability of populations of a species. This could include but is not limited to students comparing visual representations of traits of populations of a species located in different environments, conducting scientific investigations that simulate the survival of organisms of a species with different traits and analyzing data from the investigation, and engaging in argumentation from evidence from informational text and research related to the survival of populations of a species based on specific genetic traits.

In addition to *construct explanations*, students should be asked to *ask questions; plan and carry out investigations; engage in argument from evidence; obtain, evaluate and communicate information; develop and use models;* and *construct devices or design solutions.*

Previous and Future Knowledge
H.E.4 (Earth's conditions over geologic time and the diversity of organisms)

Essential Knowledge
Populations in a particular environment that have adapted to living conditions in that specific area are therefore better able to meet their survival needs and are more likely to survive and reproduce offspring with those key survival traits.

- An *adaptation* is a trait or behavior that helps an organism survive and reproduce
    - *Traits* are genetic differences that occur in a species. Traits are developed as a species adapts to its environment.
    - Organisms of a species differ from one another in many of their traits
- There can also be *variations* among species of similar populations. Variations are changes in the genes among members of the same species.
    - Variations can occur both randomly and as a result of a trait being more fit for an environment.
- *Natural selection* is the process that explains this survival and shows how species can change over time.
    - For example, certain traits or adaptations involving color, camouflage, food gathering (beaks and claws) and other physical traits, sensory abilities, or behaviors enhance the survival of a species.

Extended Knowledge
The theory of evolution is used by scientists to explain the genetic variations seen among different species. The theory of evolution is used to explain the gradual change in a species over time. Natural selection over a long period of time can lead to helpful variations accumulating while unfavorable ones that do not help a population survive, disappear. Charles Darwin was an English naturalist and geologist who was the originator of the biological theory of evolution. Studying "Darwin's Finches" is a prime example of natural selection based on physical traits that help an animal with food gathering.

Science and Engineering Practices
S.1A.6

Standard 8.E.6 The student will demonstrate an understanding of Earth's geologic history and its diversity of life over time.

Conceptual Understanding
8.E.6B Adaptation by natural selection acting over generations is one important process by which species change in response to changes in environmental conditions. The resources of biological communities can be used within sustainable limits, but if the ecosystem becomes unbalanced in ways that prevent the sustainable use of resources, then ecosystem degradation and species extinction can occur.

Performance Indicator
8.E.6B.2 Obtain and communicate information to support claims that natural and human-made factors can contribute to the extinction of species.

Assessment Guidance
The objective of this indicator is to *obtain and communicate information* to support claims that natural and human-made factors can contribute to the extinction of species. Therefore, the primary focus of assessment should be for students to *obtain and communicate from a variety of sources (informational texts, observations, data collected or discussions) to support claims* regarding the natural and man-made factors that cause extinction. This could include but is not limited to students conducting research and creating multimedia presentations on the factors contributing to the extinction of a species, and engaging in argumentation from evidence from informational text and simulations that describe or demonstrate the cause and effect relationship between natural and man-made factors on the survival of threatened and endangered species.

In addition to *obtaining and communicating information*, students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models*; and *construct devices or define solutions.*

Previous and Future Knowledge
H.E.4 (Earth's conditions over geologic time and the diversity of organisms)

Essential Knowledge
A species is extinct if no members of that species are living. Most organisms that have ever lived on Earth are now extinct.

- *Natural factors* can cause extinctions and have thus been documented and studied over the course of Earth's history.
    - Organisms that could not survive changes due to volcanic eruptions and global warming, global cooling during ice ages, changes in oxygen levels in seawater, or a massive impact from an asteroid or comet became extinct
    - Natural extinctions due to competition for resources or inability to adapt to the environment have occurred throughout geologic history
        - When species become extinct, the opportunity exists for another species to fill that ecological niche.
        - Not all extinctions that have occurred naturally throughout Earth's history have had a negative impact. Some of these extinctions have often cleared the way for new kinds of life to emerge.
- *Man-made factors* have caused extinctions in more recent times, such as the cutting of the rainforest regions, removing natural habitats, over-harvesting, and pollution.
    - Scientists have evidence to support claims that humans have contributed to the extinction of many species throughout human history, including the woolly mammoth.
    - Scientists have evidence to support the claims that many plants and animals are likely to become extinct in the near future as a result of the negative impact of human activities (clear-cutting, water and air pollution, etc.) on the environment.
    - Scientists have evidence to support the claims that human effects on the environment could threaten some biological resources that organisms, including humans, may need for survival.

Extended Knowledge
Extinctions of specific species may be studied. Debates between what man has or has not done in regards to extinction or endangerment of species may be explored. A key species to study may include the Bald Eagle or what lead to the extinction of the dinosaurs.

Science and Engineering Practices
S.1A.8